NEW ZEALAND INSTITUTE.

NOTICE TO MEMBERS.

THE publications of the New Zealand Institute consist of—

1. **Transactions,** a yearly volume of scientific papers read before the local Institutes. This volume is of royal-octavo size.

2. **Proceedings,** containing report of the annual meeting of the Board of Governors of the New Zealand Institute, abstracts of papers dealing with New Zealand scientific matters and published elsewhere, list of members, &c. The *Proceedings* are of the same size as the *Transactions*, and are bound up with the yearly volume of *Transactions* supplied to members.

3. **Bulletins.** Under this title papers are issued from time to time which for some reason it is not possible to include in the yearly volume of the *Transactions.* The bulletins are of the same size and style as the *Transactions*, but appear at irregular intervals, and each bulletin is complete in itself and separately paged. The bulletins are not issued free to members, but may be obtained by them at a reduction on the published price.

LIBRARY PRIVILEGES OF MEMBERS.—Upon application by any member to the Librarian of the New Zealand Institute or of any of the affiliated Societies such works as he desires to consult which are in those libraries will be forwarded to him, subject to the rules under which they are issued by the Institute or the Societies. The borrower will be required to pay for the carriage of the books. For a list of the serial publications received by the Library of the New Zealand Institute during 1921 see pp. 859–64.

ADDRESSES OF MEMBERS. — Members are requested to notify the Secretary of any change of address, so that the same may be noted in the List of Members.

MEMORANDUM FOR AUTHORS OF PAPERS.

The attention of authors is particularly directed to the following instructions, the observance of which will greatly aid the work of both Editor and printer. It is of importance that in typewritten as well as other copy ample space should be left between the lines.

1. All papers must be typewritten, unless special permission to send in written papers has been granted by the Editor for the time being. Wide spacing between the lines and ample margin should be left.

2. The author should read over and correct the copy before sending it to the Editor of the *Transactions.*

3. A badly arranged or carelessly composed paper will be sent back to the author for amendment. It is not the duty of an editor to amend either bad arrangement or defective composition.

4. In regard to underlining of words, it is advisable, as a rule, to underline only specific and generic names, titles of books and periodicals, and foreign words.

5. In regard to specific names, the International Rules of Zoological Nomenclature and the International Rules for Botanical Nomenclature must be adhered to.

6. Titles of papers should give a clear indication of the scope of the paper, and such indefinite titles as, *e.g.*, "Additions to the New Zealand Fauna" should be avoided.

7. Papers should be as concise as possible.

8. Photographs intended for reproduction should be the best procurable prints, unmounted and sent flat.

9. *Line Drawings.*—Drawings and diagrams may be executed in line or wash. If drawn in line—*i.e.*, with pen and ink—the best results are to be obtained only from good, firm, black lines, using such an ink as Higgin's liquid India ink, or a freshly mixed Chinese ink of good quality, drawn on a smooth surface, such as Bristol board. Thin, scratchy, or faint lines must be avoided. Bold work, drawn to about twice the size (linear) of the plate, will give the best results. Tints or washes may not be used on line drawings, the object being to get the greatest contrast from a densely black line drawn on a smooth, white surface.

10. *Wash Drawings.*—If drawing in wash is preferred, the washes should be made in such water-colour as lamp-black, ivory black, or India ink. These reproduce better than neutral tint, which inclines too much to blue in its light tones. High lights are better left free from colour, although they may be stopped out with Chinese white. As in line drawings, a fine surface should be used (the grain of most drawing-papers reproduces in the print with bad effect), and well-modelled contrasted work will give satisfactory results.

11. *Size of Drawings.*—The printed plate will not exceed 7¼ in. by 4½ in., and drawings for plates may be to this size, or preferably a multiple thereof, maintaining the same proportion of height to width of plate. When a number of drawings are to appear on one plate they should be

neatly arranged, and if numbered or lettered in soft pencil the printer will mark them permanently before reproduction In plates of wash drawings, all the subjects comprising one plate should be grouped on the same sheet of paper or cardboard, as any joining-up shows in the print. Text-figures should be drawn for reduction to a width not exceeding 4½ in. If there are a number of small text-figures they should be drawn all for the same reduction, so that they may be arranged in groups.

12. *Maps.*—A small outline map of New Zealand is obtainable at a low price from the Lands and Survey Department, Wellington, upon which details of distribution, &c., can be filled in according to the instructions given above for line drawings.

13. *Citation.*—References may be placed in a list at the end of an article or arranged as footnotes. The former method is preferable in long papers. In the list references are best arranged alphabetically, reference in the text being made by writing after the author's name, as it occurs, the year of publication of the work, adding, if necessary, a page number, and enclosing these in parentheses, thus: "Benham (1915, p. 176)." Example of forms of citation for alphabetical list:—

BENHAM, W. B., 1915. Oligochaeta from the Kermadec Islands, *Trans. N.Z. Inst.*, vol. 47, pp. 174–85.

PARK, J., 1910. *The Geology of New Zealand*, Christchurch, Whitcombe and Tombs.

When references are not in alphabetical order the initials of the author should precede the surname, and the year of publication should be placed at the end. Care should be taken to verify the details of all references—date, pages, &c.—and initials of authors should be given.

14. In accordance with a resolution of the Board of Governors, authors are warned that previous publication of a paper may militate against its acceptance for the *Transactions*.

15. In ordinary cases twenty-five copies of each paper are supplied gratis to the author, and in cases approved of by the Publication Committee fifty copies may be supplied without charge. Additional copies may be obtained at cost price.

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TRANSACTIONS

AND

PROCEEDINGS

OF THE

Royal Society of New Zealand, Wellington

NEW ZEALAND INSTITUTE

VOL. 54

(New Issue)

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ERRATA.

Page 206: For explanation of figs. 5 and 6 substitute—

FIG. 5.—Forewing of *Zelandobius confusus* (Hare).
FIG. 6.—Wings of *Zelandobius hudsoni* (Hare).

Page 574: In title, *for* Natural Self-fertilization *read* Natural Cross-fertilization.

Page 795, in formula for y, numerator of last term should read $cy\,(1-x)$, not $Cy\,(1-x)$; and in formula for x the denomination should read cy, not Cy.

NOTE.

A certain number of copies of Volume 53 were issued without Plates Nos. 24–27. If any one to whom such a defective volume was supplied will return it to the Secretary a perfect volume will be sent to replace it.

NATURAE SPECIES RATIOQUE

LAPHAM
PECKHAM
CHAMBERLIN
HOY
IRVING
ALLEN
THE WISCONSIN ACADEMY OF
SCIENCES ARTS AND LETTERS
1870 - 1920

SEMI-CENTENNIAL MEDALLION

OF THE

WISCONSIN ACADEMY OF SCIENCES, ARTS, AND LETTERS.

THE memorial medallion reproduced on the opposite page was sent to the New Zealand Institute with the following printed note:—

Herewith is sent a copy of the medallion which commemorates the fiftieth anniversary of the Academy. It was designed by the sculptor Leonard Crunelle, of Chicago.

The obverse bears the figure of Minerva with a motto from Lucretius—*Naturae species ratioque.* The reverse bears the portraits of six leading members of the Academy during the half century.

THOMAS C. CHAMBERLIN (1845–): Geologist; Professor, Beloit College; State Geologist, Wisconsin; President, University of Wisconsin; now Professor, University of Chicago.

INCREASE A. LAPHAM (1811–1875), of Milwaukee: Surveyor, naturalist, geologist; State Geologist, Wisconsin, 1873–1875.

GEORGE W. PECKHAM (1845–1914), of Milwaukee: Teacher, librarian, zoologist.

ROLAND D. IRVING (1847–1888), of Madison: Geologist; Professor, University of Wisconsin; Geologist, Wisconsin and United States Geological Surveys.

WILLIAM F. ALLEN (1830–1889), of Madison: Historian; Professor of Latin and History, University of Wisconsin.

PHILO R. HOY (1816–1892), of Racine: Physician, naturalist.

All of these men contributed largely to the success of the Academy; five were among its founders; each served as its President except Dr. Lapham, who was its first Secretary and acted in that capacity until his death.

An account of the medallion and sketches of the lives of the six members will appear in vol. 20 of the *Transactions* of the Academy, now in press.

[*Face p. ix.*

OBITUARY.

JAMES HECTOR, 1834-1907.

The time that has elapsed between the death of the principal founder of the New Zealand Institute, and the publication in the *Transactions* of the Institute of this appreciation of his work makes it clear that, in the perspective of the years, instead of sinking he rises in his position among great scientific workers.

James Hector was born in Edinburgh on the 16th March, 1834. His father was a conveyancer of note and Writer to the Signet, a friend of Sir Walter Scott, for whom he was wont to transcribe and translate old manuscripts. His mother was a niece of Dr. Barclay, founder of the Royal College of Surgeons' Museum, Edinburgh, and the teacher of Owen, Knox, Ballingall, Campbell, and a host of other surgeons and anatomists of renown.

Hector received his early training at the Edinburgh Academy and High School. At fourteen he entered his father's office, which he left on being articled to an actuary, with whom he stayed three years, at the same time attending classes at the University and School of Arts. Quite early he manifested a strong inclination towards chemistry and natural science. In November, 1852, he gave up all office-work and matriculated at Edinburgh University as a medical student, the medical course then offering the only avenue to scientific study. So it was with Owen, Huxley, and many another. Medical student though he was, and earnest as a student of medicine, he felt most strongly the spell of geology, and under its influence he developed the instincts of exploration and adventure that were to play so important a part in his later work. Every summer holiday he spent in long walking excursions in the Highlands of Scotland, in England, or in Ireland. The resourcefulness that he developed, the habit of quick and accurate observation, the general value of his student work, attracted the attention of his teachers. While attending Balfour's classes in botany he was selected by his professor to give to the Botanical Society an account of the geological and physical features of the ground gone over in excursions. There being no Chair of Geology in the university, he attended extra-academic lectures on geology, mineralogy, and palaeontology delivered by Macadam, Rose, and Page. He took the degree of M.D. in 1856. It is interesting to note that he handed in a graduation thesis on "The Antiquity of Man," the title chosen by Lyell in 1863 for one of his famous books.

For a short time after taking his degree Hector acted as assistant to Sir J. Y. Simpson, and that was the only definite medical appointment that he ever held, hearing always the insistent call of science, especially of geology.

In March, 1857, Hector was selected by Sir Roderick Murchison, Director-General of the Geological Survey of Great Britain, to be surgeon and geologist in the Government expedition to the western part of British North America, and in this work he spent four arduous and adventurous years. The leader of the expedition was Captain John Palliser, and it is of interest to take his account of the main objects to be achieved :—

"Her Majesty's Government, being anxious to obtain correct information with respect to the facilities or difficulties of communication between the Canadas and the country west of Lake Superior and north of the 49th parallel, determined, early in the year 1857, to send out an expedition to examine the present route of travel, with a view to ascertain whether it could be either shortened or rendered less formidable by any reasonable outlay, and whether if such an expenditure of capital were devoted to that object there was any prospect of a result favourable to emigration or agriculture commensurable with the sacrifice.

"The Government was also desirous of obtaining information relative to a large belt of country until now almost unknown—namely, that comprised between longitude 97° W. and the Rocky Mountains, and ranging from the 49th parallel of latitude to the North Saskatchewan.

"In addition to both these motives, the Government wished to ascertain whether any practicable pass or passes available for horses existed across the Rocky Mountains within the British territory, and south of that known to exist between Mount Brown and Mount Hooker in latitude 54° 10′." (This was the only pass then known, and horses could not cross it.)

The bulk of the scientific work fell on Hector. Not only did he share to the full the arduous work of the expedition as a whole, but when the rest of the party went into winter quarters Hector was accustomed to take a man or two, and, with Indian guides, to make long excursions on snow-shoes, and with dog-sleighs, sleeping in the snow and learning to know all parts of the territory, under the severe, almost arctic, conditions of winter, the temperature being often 50° below zero. He walked over one thousand miles in this fashion, living on pemmican or on any chance game, and often being on the shortest of rations.

He discovered and explored five different passes over the British Rocky Mountains. One of these is the famous Kicking Horse Pass, through which the trans-continental railway now runs. In his first report Palliser thus refers to the discovery: "Dr. Hector followed the Bow River right up to the main watershed of the continent, then followed it until he reached a transverse watershed which divides the waters of the Columbia and those of the Northern Saskatchewan on the one hand from those of the Kootanie and South Branch of the Saskatchewan on the other. There he found the facilities for crossing the mountains so great as to leave little doubt in his mind as to the practicability of constructing even a railroad connecting the plains of the Saskatchewan with the opposite side of the main chain of the Rocky Mountains." The names Kicking Horse River and Kicking Horse Pass were given by members of Hector's party on account of his having been kicked in the chest by his horse, an accident that nearly cost him his life. He lived to see the railway that crosses the Divide by the pass that his courage and endurance had discovered.

These two brief quotations from the report must suffice to show the magnitude of Hector's share of the work of the expedition. During the winter of 1857–58 he mapped the whole of the North Saskatchewan, from Carlton to Rocky Mountain House, a distance of nearly 9° of longitude. In his charge was the making of the maps, geographical as well as geological.

Before returning to England Hector made a geological examination of Vancouver Island, and of the goldfields of British Columbia and California, as well as of some of the mines of northern Mexico.

On his return to England he received the gold medal of the Royal Geographical Society. He received also, again at the instance of Sir Roderick Murchison, two offers of appointment: the first as Geologist at Kashmir, holding also the position of Political Agent, with large emoluments; the second as Geologist to the Provincial Government of Otago, with no extravagant emoluments. There is no need to say which Hector chose.

Arrived in New Zealand, he at once set about making a thorough exploration, especially from the point of view of geology, of the mountainous districts and the sounds of the province, work that was accomplished with great difficulty and hardship. In 1864 he was commissioned to make a tour of the colony in order to determine how its resources could best be demonstrated at the Exhibition, the first of its kind in New Zealand, to be held in Dunedin in the following year.

In 1865 he was appointed Director of the Geological Survey Department of the colony. With the small staff of assistants that could be afforded, he rapidly pushed on a geological survey of the country. Recognized as the adviser of the Government on practically all scientific matters, he had, unfortunately, to devote much time to work that hindered that which he had most at heart. Whilst the work of administration and advice was most efficiently done, he was still able to find time for an immense amount of most useful original scientific research. We may be pardoned if we give a high place to the founding of the New Zealand Institute, in 1868, among the achievements of this period of his life. From the foundation of the Institute he was for thirty-five years its Manager, and the Editor of its *Transactions*, doing this and much more as a labour of love, and so establishing a high tradition in its service. The *Transactions*, the reports of his Department, parliamentary papers, bulletins—all show the results of his untiring industry. It may safely be said that, among all the able workers that New Zealand has had, none has a greater volume of achievement, and few have reached as high a standard.

When the first Senate of the University of New Zealand met, in 1871, Sir James Hector was one of its members; in 1885 he was elected Chancellor, holding that office until his retirement in 1903. In this office he was able to render much service to the cause of higher education in New Zealand.

An idea of the high esteem in which his scientific work was held may be had from the fact that the following honours, among others, were conferred upon him:—

In 1857 he was elected a Fellow of the Royal Physical Society. In 1860 he became a Fellow of the Royal Society of Edinburgh, and of the Geological Society, London. In 1866 he was elected a Fellow of the Royal Society of London. In 1874 he received from the German Emperor, by permission of the New Zealand Government, the Order of the Golden Cross.

In 1875 he received the Order of C.M.G., and in 1886 the honour of K.C.M.G. was conferred upon him. He was elected to the honorary membership of practically all the great learned societies of Europe, America, and Australia.

On retiring from office in 1904 he paid a visit to the scene of his early labours in the Rocky Mountains, accompanied by his son Douglas. He was everywhere received with enthusiasm by the people; but the cup of joy was suddenly dashed from his lips by the death of his son and companion at Revelstoke, on the Columbia River. Returning alone, he lived at his home, near Wellington, until his death, in 1907.

In recognition of his great work for Canada, the Canadian Government has placed on the highest point of the Great Divide a monument to his memory. A monument not less enduring exists in New Zealand in the esteem in which he is held in the hearts of men. Few great men have had a more charming personality, more breadth of interest, or a greater readiness to help and encourage beginners in scientific research.

These notes of Hector's life have been taken mainly from material supplied by Lady Hector and Dr. C. Monro Hector. The present writer greatly regrets that it has been necessary to keep within narrow space-limits, realizing that a memorial volume would be more fitting than a memorial notice.

H. B. Kirk.

STEPHENSON PERCY SMITH, 1840-1922.

The late Stephenson Percy Smith was born at Beecles, Suffolk, in June, 1840. He was the eldest son of John Stephenson Smith, member of an old East Anglian family, who brought his family out to New Zealand in the ship " Pekin," which arrived at New Plymouth on the 7th February, 1850. Here the family settled and took part in the opening-up of what was for many years an almost isolated district. Mr. Smith joined the Survey Department at New Plymouth in 1855, and later became an assistant surveyor. He followed up his profession until his retirement from the service in 1900.

In 1857–58 Mr. Smith, together with several young companions, undertook an extended walking-tour across the Island from Taranaki to the Bay of Plenty by way of Mokau, Taupo, and Rotorua, returning by the Whanganui route. That trip was marked by the careful noting of much interesting data concerning the Maori and the natural productions of the districts traversed, a habit that Mr. Smith cultivated throughout his long life.

During the years 1859–63 Mr. Smith was connected with the Native Land Purchase Department in the Auckland District. The year 1865 found him back at Taranaki, where he pursued his profession for years under difficult and often extremely dangerous conditions. He spent the year 1868 in the triangulation and subdivision of the Chatham Islands. In the following year he returned to Taranaki, and for about six years he was engaged in the major triangulation of the North Island. In 1877 he was appointed Chief Surveyor of the Auckland District, and in 1882 he became Assistant Surveyor - General. In 1889 he was appointed to the highly responsible position of Surveyor-General, which he held until his retirement in 1900 after forty-five years of service. That long period of service was marked by unusual ability and devotion to duty, and by the confidence of succeeding Governments.

The unusual qualities possessed by Mr. Smith led to his being entrusted with various missions and tasks outside his professional activities. Thus we have his interesting work on the eruption of Tarawera of 1886, which shows that, had he devoted himself to geology, that science would have gained an able interpreter. In 1887 he was sent to the Kermadec Islands in order to take possession of that group, and in the latter " nineties " was appointed Chairman of the Urewera Commission. In 1902 he was requested by the Governor of New Zealand to proceed to Niue in order to institute a system of government for that island.

Mr. Smith will probably be best remembered by his remarkable work in Polynesian ethnology. He had an intimate knowledge of old-time Maori life, the language, history, and customs of our native folk, as also a remarkable acquaintance with those of the various far-scattered divisions of the Polynesian race in northern isles. He collected a great mass of data concerning these subjects, and in 1892 he was the chief agent in the formation of the Polynesian Society. The recording of the great volume of ethnological matter contained in the thirty-one volumes of the journal of that society may be placed to the credit of Mr. Smith, who acted as editor throughout that lengthy period.

Apart from his remarkable achievement in the conduct of the above journal, Mr. Smith published much valuable matter in book form. Of these the most notable is *Hawaiki—The Original Home of the Maori*, published in 1898 (fourth edition 1921); while others were as follows: *The Kermadec Islands* (1887); *The Peopling of the North* (1898); *Niue Island and its People* (1903); *Maori Wars of the Nineteenth Century* (1904; second edition 1910); *History and Traditions of the Maoris of the West Coast* (1910); *The Lore of the Whare Wananga* (Part 1, 1913; Part 2, 1915).

In recognition of his valuable work in Polynesian ethnology he was, in 1919, awarded the Hector Medal by the New Zealand Institute, of which Institute he was one of the first twenty Fellows elected in 1920. He was corresponding member of the Royal Anthropological Institute of Great Britain, of the Societa d'Anthropologia d'Italia, of the Royal Geographical Society of Australasia, and of the Hawaiian Historical Society.

In the years that lie before, the result of Mr. Smith's talents and indefatigable industry will assuredly be highly appreciated by students of Maori enthnology and the early history of New Zealand and Polynesia. He was a born collector (in itself a rare quality) and a facile writer—a rare combination.

Above all, throughout the long life of Stephenson Percy Smith shone forth the powers and wide influence of sterling character. He died at his residence, "Mataimoana," New Plymouth, on the 19th April, 1922.

Elsdon Best.

DAVID SHARP, 1840-1922.

Dr. David Sharp, one of the most distinguished entomologists of the present time, died at his residence, Lawnside, Brockenhurst, England, on Sunday, the 27th August, 1922. He was born at Towcester, Northants, on the 15th October, 1840. He studied medicine, first at St. Bartholomew's Hospital, London, and subsequently at Edinburgh, where, in 1866, he graduated as M.B. and C.M. In 1867 he was appointed to the Crichton Institution at Dumfries, but after 1883 he was enabled to discontinue active medical practice and devote himself entirely to scientific work. In 1890 he accepted the charge of the insect collections of the University Museum of Zoology at Cambridge. This curatorship he retained until 1909, when he built a house at Brockenhurst, overlooking the New Forest, whither he retired until the time of his death.

As is so frequently the case, his first attention was given to the Lepidoptera, but his energies were soon transferred to the Coleoptera, with which order his name will be inseparably associated in the future.

The magnitude of Dr. Sharp's entomological work may be realized when it is known that in the Royal Society's Catalogue of Scientific Papers and the *Zoological Record* there are entered no less than 257 papers written by him. In 1891 he became responsible editor of the *Zoological Record*.

To him are due two excellent catalogues of the English Coleoptera, issued in 1871 and 1893, the latter in conjunction with the Rev. Canon Fowler. In the *Scottish Naturalist* he published (1871–79) an exhaustive annotated list of Coleoptera north of the border. His most important contribution to the *Transactions of the Entomological Society of London* was an essay, issued in 1912 (in conjunction with Mr. F. Muir), "On the Comparative Anatomy of the Male Genital Tube in Coleoptera." His best book is the treatise on "Insects," forming the greater part of two volumes of the *Cambridge Natural History* (1895–99). Of this it can safely be said that no work of equal value on general entomology has been produced in Britain since Westwood's *Introduction*, which appeared more than half a century before.

Dr. Sharp's extensive collection of Coleoptera from all parts of the world was, a few years before his death, acquired by the nation: the whole of his library was purchased by the Cawthron Institute, Nelson.

He joined the Entomological Society of London in 1862, and at the time of his death he was the senior surviving Fellow. He was Vice-President on four separate occasions, and President in 1887 and 1888. In 1890 he was elected a Fellow of the Royal Society. He was honorary or corresponding member of most of the chief entomological societies throughout the world, and he specially valued his connection with the New Zealand Institute. Of this he was the oldest surviving honorary member, having been appointed in 1877, the date of the next oldest being as recent as 1890.

Dr. Sharp's influence on New Zealand entomology has been very great. From early in the "seventies" of last century until about the year 1888 he was in constant correspondence with that indefatigable collector the late Mr. R. Helms, of Greymouth, and as a result of the joint labours of these two naturalists some of our most conspicuous and remarkable beetles were first made known to science. Later on, the writer of this notice also had the privilege of corresponding with Dr. Sharp, and it was entirely due to his influence and encouragement that a paper appeared in the *Transactions of the New Zealand Institute* for 1893 stressing the urgent necessity for the formation of extensive collections of New Zealand animals and plants (including, of course, insects) before the further advance of settlement had resulted in the extermination of many interesting species.

To Dr. Sharp's very early association with the great English philosopher Herbert Spencer may probably be ascribed his cautious and extremely logical mode of thought. Whilst keeping closely in touch, throughout his long life, with modern evolutionary doctrines, he never allowed himself to be unduly led away by enthusiasm. He always kept his great store of facts steadily in view when attempting to test the truth of theories supposed to explain the multifarious phenomena of insect-life.

G. V. Hudson.

CHARLES ALFRED EWEN, 1852-1921.

The late Mr. C. A. Ewen was born at Birmingham, England, in 1852—a son of Walter Ewen, who came to New Zealand in 1854, and settled in Auckland. He was educated in the Auckland High School, where he won the medal for special ability.

After a visit to England in 1874 he returned to New Zealand, and in 1876 joined the staff of the Bank of New Zealand, becoming in due course manager of several branches—Waipawa, New Plymouth, &c. About 1895 he joined the New Zealand Insurance Company as manager of their Wellington branch, and in 1907 was offered and accepted the general managership of the Commercial Union Assurance Company, which position he held up to the date of his death.

He was keenly interested in sport, having himself in his early days been a representative footballer of the Auckland Province ; he was a pronounced Imperialist, was a Fellow of the Royal Colonial Institute, a Financial Member of the Executive of the Dominion War Relief Association, for several years a Vice-President of the Wellington Club, and President of the New Zealand Council of Underwriters. He was also a trustee of the Wellington Diocese, a member of the Wellington Chamber of Commerce, and Government representative on the Board of Science and Art. He was appointed Government representative on the New Zealand Institute in 1910, was made Honorary Treasurer in 1912, and held both positions at the date of his death.

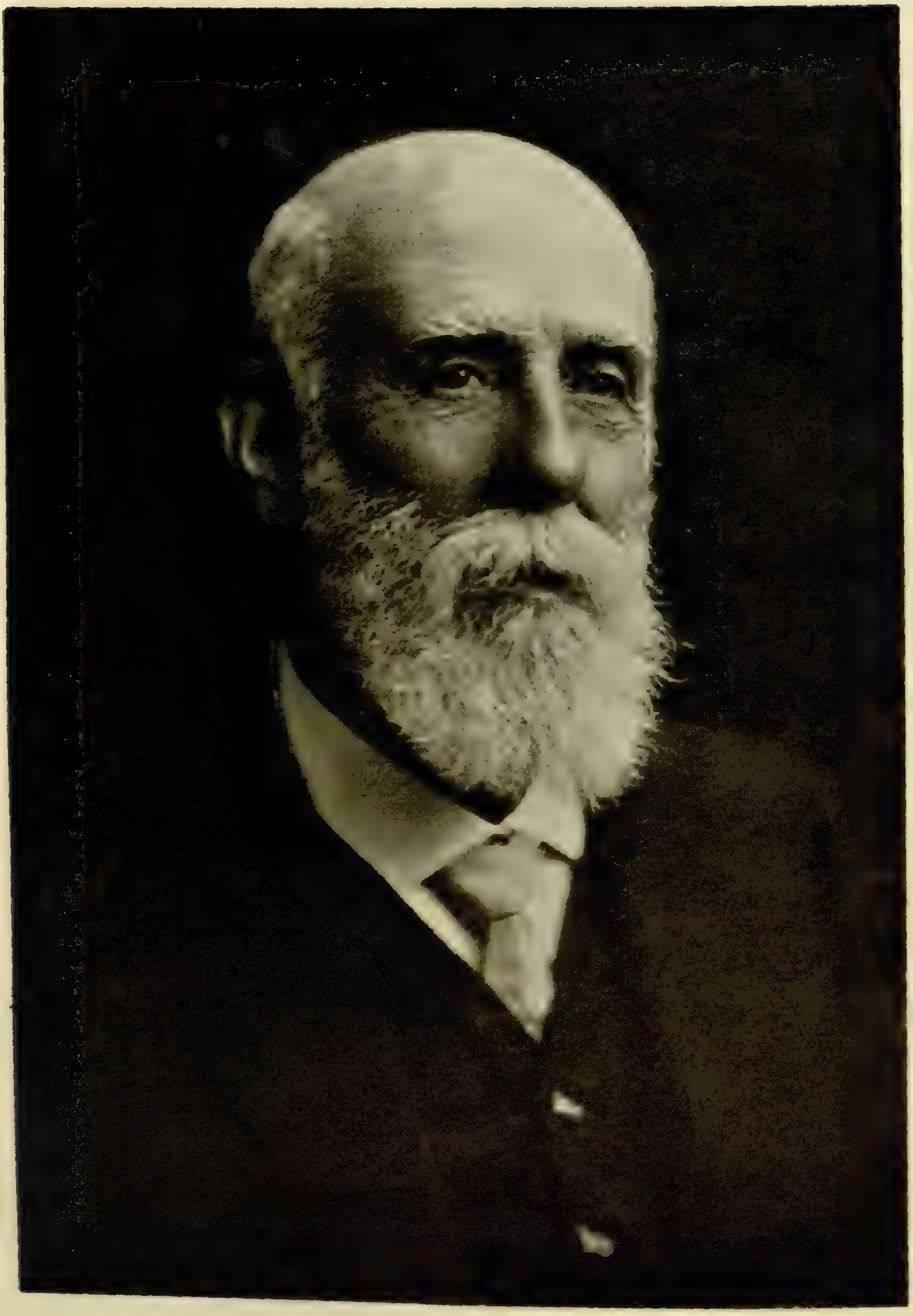
He was keenly interested in science and art, and his collection of books dealing particularly with New Zealand and Australia, made during his friendship with the late A. H. Turnbull, was very extensive, as, too, was his collection of Maori weapons and implements.

He lived the quiet private life of a busy business man and assiduous collector, and, whilst he had only one paper in the *Transactions* of the Institute, he materially assisted the Institute in his position of Honorary Treasurer.

He married, in 1883, Jane Douglas, daughter of the late Frederick Sutton, of Hawke's Bay, M.P. for that district for a number of years, and died at his home on 9th April, 1921, leaving a widow and two daughters.

Johannes C. Andersen.

Face p. xvi.]



T. F. Cheeseman

THOMAS FREDERIC CHEESEMAN, 1846-1923.

By the death of Thomas Frederic Cheeseman on the 15th October, 1923, the New Zealand Institute has lost a highly distinguished Fellow whose name must be added to that select band—Colenso, Kirk, Haast, Hector, and Hutton—who, with himself, working in this country, have laid a lasting foundation on which is being erected the splendid edifice of New Zealand natural history.

Cheeseman, though nominally an Englishman through being born at Hull, in Yorkshire, in 1846, was in reality a New-Zealander, since he came to the colony with his parents when only eight years of age, and was educated first at the Parnell Grammar School and later at St. John's College, Auckland. His father, the Rev. Thomas Cheeseman, was at one time a member of the old Auckland Provincial Council, and took a prominent part in the public life of the day.

It is not easy to say what led Cheeseman to commence a serious study of our flora, but probably the stimulus to a natural bent was Hooker's *Handbook*, together with the founding of the New Zealand Institute. At any rate, by 1872—fifty-one years ago—he had acquired, unaided in any way, so sound a knowledge of the plants of his neighbourhood that he was able to publish an accurate and comprehensive account of the plant-life of the Waitakarei Hills. This paper is far from being obsolete, for it is the sole record of a vegetation which is now profoundly modified.

In 1874 Cheeseman was appointed Secretary of the Auckland Institute and Curator of the Museum, then in its early infancy. How far-reaching for the scientific advancement of New Zealand, and indeed for the general benefit of the country, this apparently unimportant appointment was, no one could possibly foresee; yet it has led to the gathering together of the invaluable collections of the Auckland Museum, and to botanical studies, not academic only, but of high significance for agriculture, horticulture, and forestry. These studies were carried on diligently up to his death, hardly a year having passed without some communication appearing from his pen. Primarily a botanist, he belonged nevertheless to that class of naturalists, common enough before these days of specialization, who took an interest in all branches of natural history. Thus, of his 101 papers and books, twenty-two deal with zoological or ethnological subjects; indeed, it was this wide knowledge which fitted him so eminently for his museum activities.

But it was as a botanist that Cheeseman stood pre-eminent, and it is his work in floristic botany which has made his name widely known in all lands. At the time his researches commenced, the greater part of New Zealand was almost unknown botanically, so that a keen search for plants in all directions was demanded; fresh material was also essential for the accurate study of many species admitted by Hooker. During his vacations, therefore, Cheeseman assiduously sought to remedy this state of affairs, and many were his excursions. The most important communications from his pen on this head concern the Nelson Provincial District, the Kermadec and Three Kings Islands, and the area from Mangonui to the far north; but these by no means reflect all his activities in the field, nor give any

idea of the number of species he discovered or specially investigated. All this is better reflected in his *Manual*, wherein are indicated the many localities he visited and the species he described. In some of his excursions he was accompanied by his friend the late Mr. J. Adams, of the Thames High School, and the names *Senecio Adamsii* and *Elytranthe Adamsii*, bestowed by Cheeseman, are a fitting memento of their comradeship.

Cheeseman's explorations were not confined to the New Zealand Botanical Region; he also visited Polynesia, and published in the *Transactions of the Linnean Society* a comprehensive account of the flora of Rarotonga, the chief island of the Cook Group. His general botanical knowledge was wide, especially of systematic botany; he also had the greatest sympathy for other branches of the science, and perceived plainly the present-day trend—for had he not closely watched the botanical development of fifty years' unparalleled activity? Thus, in his own domain, although during the greater part of his career he based his work on the Linnean conception of species, in recent years his opinion changed in no small degree in this regard, and he accepted, or defined, groups of individuals as species which he would previously have merged. In other words, he possessed the true scientific spirit, in that he was open to conviction, and would deliberately follow a new path, even if so doing clashed with his former opinions.

Cheeseman's botanical publications fall into several classes; many, along with the work of others, paved the way for a complete flora of New Zealand. Then there was the actual flora he produced in 1906, entitled *The Manual of the New Zealand Flora*, to which must be added his and Hemsley's *Illustrations of the New Zealand Flora* (1914). Then come his writings of a philosophical character which deal with the origin of the New Zealand subantarctic flora, and an early paper treating of the naturalized plants of the Auckland Provincial District. Finally, amongst his earlier writings also are several papers dealing with the pollination of certain species—a matter then receiving great attention through the influence of Darwin.

There is not space available for a full account of the scope of the above writings; all, even the shortest, were distinguished by those characteristics which their gifted author possessed to an extreme degree—sound judgment, clarity of expression, and accuracy. Above all, he had the supreme gift of infinite patience: all views expressed were the result of much cautious deliberation; the hurried methods of the present day were not for him. And in this spirit he approached his classic work, *The Manual of the New Zealand Flora*, with the result that it can be used with all confidence in the certain knowledge that it contains the well-considered conclusions of a master mind. As for this flora, it stands out the equal of any of that brilliant series of floras dealing with various parts of the British Empire which were conceived, and in part executed, by Bentham and Hooker.

Hand in hand with his botanical research went on the development of the Auckland Museum, which, during the fifty years of his direction, developed into an institution of high rank, especially distinguished—such was his many-sided knowledge—by what is probably the most extensive collection extant illustrating Maori ethnology. A peculiarly important addition will be Cheeseman's almost complete herbarium of the flowering-plants and vascular cryptogams of the Dominion, which some short time ago he presented to the Auckland Institute—a splendid gift, invaluable for all students of the flora.

To a scientific worker in a far-away corner of the earth honours come slowly. Nevertheless it would have been astonishing had Cheeseman's many claims for recognition been overlooked. For many years New Zealand itself had nothing to offer. Even the University does not honour itself, as do other universities, by conferring degrees upon distinguished men. But Cheeseman was early elected a Fellow of the Linnean Society of London, and, a little later, of the Zoological Society also. But honours far more distinguished came to him—first of all, a Corresponding Membership of the Botanical Society of Edinburgh, and this year one of the highest science can offer, the Gold Linnean Medal of the Linnean Society, a distinction open to zoologists and botanists throughout the world; further, had he lived, he would almost certainly have been elected a Fellow of the Royal Society. Then the New Zealand Institute made him its President in 1911, which is the highest honour a scientific man can attain in the Dominion, and in 1918 he was awarded the Hector Memorial Medal and Prize for his botanical researches, and the succeeding year he was made an original Fellow of the New Zealand Institute.

After all, the gaining of honours is far from being the crown of the gifted man of science: rather is it the admiration of those who best know his work, and, above all, the knowledge that such work is influencing his fellow-workers, old and young. It is indeed difficult to estimate how great has been the influence of Cheeseman upon botanical research in New Zealand. His works must perforce be in the hands of all pursuing studies concerned either with the flora or the vegetation, and must be consulted daily. Nor will this influence lessen with his lamented death; it will vastly increase. Happily, the great botanist lived to round off his life's work—the revised edition of his flora. How greatly do we botanists of this country, if I may speak for my friends and colleagues, rejoice that he had the satisfaction of finishing his task! How greatly do we deplore that he did not live to see his labours materialized, and to receive our acclamation!

L. Cockayne.

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NEW ZEALAND INSTITUTE.

ROLL OF HONOUR

SHOWING MEMBERS OF THE INSTITUTE WHO WERE ON ACTIVE SERVICE DURING THE WAR.

Name.	Available Details of Service.	
	WELLINGTON PHILOSOPHICAL SOCIETY.	
E. H. Atkinson ..	Lieutenant, Royal Naval Volunteer Reserve.	
C. M. Begg ..	Colonel, N.Z. Medical Corps	C.B., C.M.G. Died of sickness.
Val. Blake ..	Lieutenant, Canterbury Infantry	Killed in action.
F. K. Broadgate ..	Lieutenant, N.Z. Engineers	Killed in action
P. W. Burbidge ..	Sergeant, 34th Specialists.	
W. H. Carter ..	Canterbury Infantry.	
L. J. Comrie ..	Sergeant-Major, 36th Reinforcements.	
V. C. Davies ..	Regimental Sergeant-Major, 1st N.Z. Rifle Brigade	
W. Earnshaw ..	Engineer Lieut.-Commander, R.N.	
C. J. Freeman ..	N.Z. Rifle Brigade.	
C. Freyberg ..	Lieutenant, West York (Prince of Wales's Own) Regiment.	
J. G. B. Fulton ..	Corporal, 10th Reinforcements.	
H. E. Girdlestone ..	Company Sergeant-Major, Wellington Infantry	Killed in action.
H. Hamilton ..	Sub-Lieutenant, Royal Naval Volunteer Reserve	
C. G. Johnston ..	Lieutenant, 1st N.Z. Rifle Brigade	Killed in action
G. W. King ..	Lieutenant, N.Z. Tunnelling Company.	
E. Marsden ..	Major (temp.), N.Z. Engineers	M.C.; mentioned in despatches.
J. M. Mason ..	Lieut.-Colonel, N.Z. Medical Corps.	
D. McKenzie ..	Trooper, Wellington Mounted Rifles.	
H. M. Millar ..	Sergeant, N.Z. Engineers' Divisional Signalling Company.	
W. L. Moore ..	Captain, N.Z. Field Artillery	Mentioned in despatches.
T. D. M. Stout ..	Lieut.-Colonel, N.Z. Medical Corps	D.S.O.
R. M. Sunley ..	Corporal, Specialists.	
W. M. Thomson ..	Captain, N.Z. Medical Corps.	
H. S. Tily ..	Sergeant, N.Z. Field Artillery.	
H. Vickerman ..	Major, commanding N.Z. Tunnelling Company	D.S.O., O.B.E.; mentioned in despatches.
C. J. Westland ..	Corporal, N.Z. Machine Gun Corps.	
	AUCKLAND INSTITUTE.	
F. L. Armitage ..	Captain, N.Z. Medical Corps.	
S. B. Bowyer ..	Gunner, N.Z. Field Artillery.	
R. Briffault ..	Captain, N.Z. Medical Corps.	
P. H. Buck (Te Rangi Hiroa)	Major, N.Z. Medical Corps	D.S.O.
S. Cory-Wright ..	Captain, N.Z. Engineers, Divisional Intelligence Officer	M.C.
W. J. Crompton ..	1st Battalion, Otago Regiment.	
F. N. R. Downard	Lieutenant, N.Z. Rifle Brigade.	
G. Fenwick ..	Captain, N.Z. Medical Corps.	

Roll of Honour—*continued.*

Name.	Available Details of Service.	
	Auckland Institute—*continued.*	
R. H. Gunson ..	Lieutenant, Motor Boat Reserve.	
G. H. Hansard ..	Sergeant-Major, 33rd Machine Gun Corps.	
D. Holderness ..	Lieutenant, N.Z. Engineers.	
R. T. Inglis ..	Captain, N.Z. Medical Corps.	
J. C. Johnson ..	Captain, N.Z. Medical Corps.	
C. W. Leys ..	Lieutenant, Royal Naval Volunteer Reserve.	
K. Mackenzie ..	Captain, N.Z. Medical Corps.	
H. A. E. Milnes ..	Lieutenant, Auckland Infantry Regiment ..	Killed in action.
W. R. B. Oliver ..	Corporal, Canterbury Infantry.	
G. Owen ..	Lieutenant, N.Z. Rifle Brigade and N.Z. Engineers.	
A. C. Purchas ..	Major, N.Z. Medical Corps.	
E. Robertson ..	Captain, N.Z. Medical Corps.	
C. B. Rossiter ..	Captain, N.Z. Medical Corps.	
T. C. Savage ..	Captain, N.Z. Medical Corps	Died of sickness.
Rev. D. Scott ..	Chaplains Department, N.Z. Expeditionary Force.	
H. L. Wade ..	Captain, Auckland Mounted Rifles.	
F. Whittome ..	Corporal, N.Z. Rifle Brigade.	
	Philosophical Institute of Canterbury.	
H. Acland ..	Colonel, N.Z. Medical Corps.	
G. E. Archey ..	Captain, N.Z. Field Artillery.	
J. W. Bird ..	Sergeant-Major, Instructional Staff.	
F. J. Borrie ..	Captain, N.Z. Medical Corps.	
F. M. Corkill ..	Captain.	
William Deans ..	Captain, Canterbury Mounted Rifles.	
A. A. Dorrien-Smith	Major.	
A. Fairbairn ..	Captain.	
H. D. Ferrar ..	Trooper, N.Z. Mounted Rifles.	
C. E. Foweraker ..	Corporal, N.Z. Medical Corps.	
F. G. Gibson ..	Captain, N.Z. Medical Corps.	
J. Guthrie ..	Captain, N.Z. Medical Corps.	
W. Irving ..	Captain, N.Z. Medical Corps.	
L. S. Jennings ..	Captain, Otago Regiment	Killed in action.
H. Lang ..	2nd Lieutenant, N.Z. Rifle Brigade ..	Killed in action.
E. Kidson ..	Captain, Royal Engineers.	
G. MacIndoe ..	Signaller, Otago Infantry Brigade	Killed in action.
P. S. Nelson ..	Private, Canterbury Regiment	Killed in action.
F. S. Oliver ..	Sergeant, Headquarters Instructional Staff.	
H. V. Rowe ..	Sergeant-Major, Headquarters Instructional Staff.	
Sir R. H. Rhodes	Colonel, Red Cross Commissioner.	
A. Taylor ..	Captain, N.Z. Veterinary Corps.	
G. T. Weston ..	Lieutenant, Canterbury Regiment.	
F. S. Wilding ..	Captain, N.Z. Field Artillery.	
J. P. Whetter ..	Captain, N.Z. Medical Corps.	
A. M. Wright ..	Captain, N.Z. Medical Corps.	
	Otago Institute.	
S. C. Allen ..	Captain, N.Z. Medical Corps.	
R. Buddle ..	Surgeon, H.M. Ships "Crescent," "Cumberland," and "Warwick"	Mentioned in despatches.
L. E. Barnett ..	Lieut.-Colonel, N.Z. Medical Corps	C.M.G.
F. C. Batchelor ..	Lieut.-Colonel, N.Z. Medical Corps.	
Rev. D. Dutton ..	Chaplain, N.Z. Expeditionary Force.	
Cuthbert Fenwick	Sergeant, N.Z. Medical Corps.	
Mackie ..	Sergeant, N.Z. Expeditionary Force ..	M.M.

ROLL OF HONOUR—*continued.*

Name.	Available Details of Service.	
	OTAGO INSTITUTE—*continued.*	
E. J. O'Neill ..	Lieut.-Colonel, N.Z. Medical Corps	C.M.G., D.S.O.
T. R. Overton ..	Lieutenant, N.Z. Pioneers.	
H. P. Pickerill ..	Lieut.-Colonel, N.Z. Medical Corps	O.B.E.
R. Price ..	Major, Otago Infantry	Killed in action.
E. F. Roberts ..	Captain, Royal Engineers.	
S. G. Sandle ..	Major, N.Z. Expeditionary Force.	
F. H. Statham ..	Major, Otago Infantry	Killed in action.
W. D. Stewart ..	Lieutenant, Otago Infantry.	
W. A. Thomson ..	N.Z. Machine Gun Corps.	
R. N. Vanes ..	Lieutenant, N.Z. Expeditionary Force.	
D. B. Waters ..	Captain, N.Z. Tunnelling Corps.	
H. F. H. Whitcombe	Gunner, N.Z. Field Artillery.	
	MANAWATU PHILOSOPHICAL SOCIETY.	
E. C. Barnett ..	Captain, N.Z. Medical Corps.	
D. H. B. Bett ..	Captain, N.Z. Medical Corps.	
A. A. Martin ..	Major, N.Z. Medical Corps	Killed in action.
J. Murray ..	Lieutenant, Auckland Infantry.	
H. D. Skinner ..	Private, Otago Infantry	D.C.M.
W. R. Stowe ..	Major, N.Z. Medical Corps.	
	HAWKE'S BAY PHILOSOPHICAL INSTITUTE.	
H. F. Bernau ..	Captain, N.Z. Medical Corps.	
J. P. D. Leahy ..	Major, N.Z. Medical Corps.	
E. F. Northcroft ..	Corporal, 41st Reinforcements.	
E. G. Wheeler ..	Corporal, Wellington Regiment.	
G. T. Williams ..	Wellington Mounted Rifles	Died of sickness.
	NELSON INSTITUTE.	
F. A. Bett ..	Captain, N.Z. Medical Corps.	
	WANGANUI PHILOSOPHICAL SOCIETY.	
Morris N. Watt ..	Corporal, N.Z. Medical Corps.	

NOTE.—The roll is as complete as it has been found possible to make it. The Editor would be glad to be notified of any omissions or necessary amendments.

PRESIDENTIAL ADDRESS.

The following is the presidential address delivered before the New Zealand Institute on the 31st January, 1922, at Wellington, by Thomas Hill Easterfield, M.A., Ph.D., F.I.C., F.N.Z.Inst., Director of the Cawthron Institute of Scientific Research, and Emeritus Professor in Victoria University College :—

In my presidential address last year I spoke to the general public on some aspects of scientific research, and I outlined certain schemes whereby research might be forwarded for the intellectual and scientific advancement of our country. To-day I address the Board of Governors only, and I know it is needless to impress upon them the importance of scientific investigation, for the members of this Board have an honourable record of published investigations, and to my certain knowledge are anxious to advance the cause and the progress of scientific research.

Nevertheless, I feel that greater co-operation is needed than exists at present amongst New Zealand men of science in the effort made on behalf of research. This want has been felt in other countries ; and the United States notably has made great efforts, by means of the National Research Council, to co-ordinate the research activities in that country of amazing progress. Certain correspondence has passed between the National Research Council and our own Institute during the year, and I trust we shall be able to co-operate with them in research work upon certain problems of the Pacific Ocean. It is, however, difficult to see how great progress in the matter of organization of research can be made without financial assistance, and it would certainly appear that, owing to the changed financial situation, the time has come for some complete change of policy in New Zealand. Great as is the value of the contributions to science made by those who are bearing the whole cost of their investigations, it must be recognized that the number of those who are in a position to do work in this manner is limited. Moreover, in the case of some of the sciences, the apparatus and material required are of such an expensive nature that few amateurs can afford to supply the equipment with which such work can be carried out efficiently. The work, however, must be done, and we as an Institute shall be lacking in our sense of duty to the country in which we live if we do not exert great efforts in order that the difficulties may be overcome. It is worth while considering whether the Councils of the societies affiliated to the New Zealand Institute should not be circularized and asked to suggest methods whereby the research spirit may be fostered in their own districts, so that greater attention may be given to investigation in pure and applied science throughout the Dominion. It must be admitted that we have not yet educated the public of New Zealand to the point of recognizing that national progress is largely dependent upon the continuous application of scientific discovery to technical problems, and that the development of technical science depends directly upon discovery in the realms of chemistry, physics, and biology.

I regret to inform you that the research grant, which last year Cabinet had raised from £250 to £2,000, has been brought down to £400, and that it is possible that no new grants will be made during the coming year.

Financial difficulty is also facing the Institute in other directions. Those who have made a careful study of the balance-sheets supplied by our Treasurer will have noticed that our liabilities are £678 in excess of our available assets, notwithstanding that the statutory grant was last year increased under the New Zealand Institute Amendment Act from £500 to £1,000. The deficit is mainly due to the fact that the cost of printing the *Transactions* has risen from approximately 14s. 4d. per page in 1913 to nearly £2 in 1921. In view of the financial position, I have taken upon myself the very grave responsibility of overriding a decision of the Standing Committee, arrived at before the printer's account had been received, to the effect that the printing of certain papers should be proceeded with at once, and have instructed the Hon. Editor to hold up the work until a resolution of this meeting can be arrived at.

It is interesting to notice that the New Zealand Institute is in the same difficulty as the scientific societies in Great Britain and Europe, most of which have found it necessary to increase, and in some cases to double, the subscriptions of their members. Notwithstanding this increase, many of the societies are publishing their *Transactions* at a loss, which in some cases is being met out of reserve funds. The position of the New Zealand Institute, however, is different from that of any other learned society with which I am acquainted, in that its members are the members of the affiliated societies, and therefore pay no subscription to the New Zealand Institute, though of recent years a levy of 2s. 6d. has been raised for each copy of the *Transactions* supplied to them. This position cannot, of course, arise in the case of the similar societies, the Royal Societies in the various Australian States, for the members of these bodies pay their subscription direct to the society, which is thus enabled to finance its publications.

It would seem that there are several methods which might be adopted in order to meet the present financial situation :—

(1.) The Institute might decide to cease all publication until the general situation improves. This would be a most drastic action, and one which I should personally oppose. Apart from the fact that it is almost unthinkable to stop after fifty-two years of consecutive publication, it is very doubtful if the situation would be improved. Possibly all the societies would withdraw from affiliation to the New Zealand Institute, which would *ipso facto* cease to exist.

(2.) The size of the volume might be reduced by a stricter censorship on the part of our able Editor and the Committee of Publication. If this method of reduction of cost were effected with judgment, probably little harm would ensue. It is a method which has been effectively applied for many years by several of the best-known London and Continental societies. It must be admitted, I think, that some authors are unduly prolix, and that by reducing the length of their papers they would add to their effectiveness.

(3.) Illustrations might be reduced largely. In the case of some classes of papers this course of action might do no harm; in other cases it would deprive the papers of much of their interest. Few biologists would value a description of a new genus of plant or animal without carefully produced figures of anatomical details.

(4.) Authors might be charged with a portion of the cost of printing their papers and of producing the accompanying plates. This plan has recently been adopted by at least one London society. It is, however, hard upon the investigators, and would be particularly hard upon the younger members of our Institute, workers who are seldom in receipt of a salary which provides more than a bare subsistence.

(5.) The levy on the local societies might be raised to 10s. per copy of the *Transactions*. The volume is certainly worth this sum.

(6.) The levy on the societies might be dropped altogether and the volume supplied only to those members who desired it, a sum being charged which would pay for the cost of production. I fear that the introduction of this method at the present time of general stringency might increase rather than diminish our financial difficulties.

(7.) An appeal might be made to our members to establish a printing fund by voluntary contributions. I do not doubt that a large number of our older members who have for years received the benefits of an interesting journal, for which they have paid nothing directly, would be willing to subscribe to such a fund, and thus help in the publication of the papers contributed by younger members.

The above suggestions I commend to the earnest attention of the Board of Governors, feeling sure that their deliberative wisdom will enable the Institute to escape from a situation which, though embarrassing, is certainly not to be regarded as desperate.

TRANSACTIONS.

TRANSACTIONS

OF THE

NEW ZEALAND INSTITUTE.

Art. 1.—*Palaeozoic and Mesozoic Seas in Australasia.*

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The Stratigraphic and Structural Relationships of Australia and New Zealand: an Historical Sketch.

More than forty years ago Hector (1879) delivered in Sydney an address on the "Geological Formations of New Zealand compared with those of Australia," which was used by Suess (1888) in his comparison of the relation of the eastern part of South America to the Andean zone on the one side of the Pacific with that of western Australia to eastern Australia and New Zealand on the other. The former unity of these two last regions had already been indicated in Neumayr's (1883) chart of the

Jurassic world, in which, in place of the Tasman Sea, a restricted southward opening, "Queensland Gulf," lay between the continental mass of Australia and a long promontory stretching from New Guinea through New Caledonia and New Zealand, where is now a somewhat elevated region of the ocean-floor. This feature has characterized most of the later palaeogeographic maps of Australasia drawn at various periods by David (1893), Koken (1893–1907), Frech (1897–1902), Lapparent (1900–6), Arldt (1907), Hedley (1909), Haug (1911), Schuchert (1916), but is not present in those of Lemoine (1906), while Walkom (1918) recognizes the presence of the gulf in Triassic but not in Jurassic times.*

As a geologist trained in Australia, the writer, when settling in New Zealand, was naturally attracted to the problem Hector set himself, and especially towards its palaeogeographic aspect, and he has attempted in the sequel to summarize once more our modern knowledge of the broader features of Australasian stratigraphy. As Walkom (1918) has clearly indicated, "the palaeogeography of the Australasian region involves a consideration of the structure of the western Pacific region"; and we shall therefore commence the discussion by giving a brief *résumé* of the conceptions that have been advanced concerning this broader problem in whole or in part.

Basing his opinions on sections drawn through Canterbury and Westland by von Haast, and through Otago by Hector, Hochstetter (1867) stated that "only the eastern half of a complete mountain chain has been preserved [in New Zealand], while the western half is buried in the depths of the main." Hutton (1875) suggested that the Otago region in Devonian times was depressed beneath the sea, and emerged again in Permian times, when New Zealand formed a very subordinate part of a large continent which stretched far to the northward. Subsidence of all but the southern part followed, succeeded by a slight elevation, deeper subsidence, and this again by the great Alpine folding, believed by Hutton to have occurred in the Middle Jurassic times. This was part of a large movement which probably resulted in the upheaval of an Antarctic continent extending to South America, as shown by the fact that all the formations later than this upheaval contain fossils identical or closely connected with those of Patagonia and Chile. Subsidence followed, New Zealand was reduced to a chain of islands, and has since remained isolated from any large continental area.

Clarke (1878) pointed out that there are no marine Tertiary rocks on the eastern coast of Australia or Tasmania, and that this may indicate that the eastern extension of Australia has been cut off by a general subsidence. "This has some support in the fact that there is a repetition of the Australian formations in the Louisade Archipelago, New Caledonia, and New Zealand. The intervening ocean may therefore be supposed to cover either a great synclinal depression or a denuded series of folds" (Clarke).

Hector's (1879) correlation of the geological formations of Australia and New Zealand is a close approximation to modern conclusions, as may be seen from the accompanying table. Hector held that New Zealand

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* Among other palaeogeographic maps or summaries dealing with Australia as a whole or in part with several or with single formations are those of Jensen (1908, 1912), Basedow (1909), Gregory (1910), David (1907, 1911, 1914, 1919), Walkom (1913), Süssmilch (1919), Andrews (1916), Benson (1921).

TABLE OF CORRELATIONS OF GEOLOGICAL FORMATIONS IN AUSTRALIA AND NEW ZEALAND SUGGESTED BY HECTOR IN 1879.

New Zealand.			Australia.	
Formation.	Age assigned by Hector.	Modern Age-determination.	Coeval Formation according to Hector.	Modern Age-determination.
Amuri limestone, greensand, &c., and coal-measures (also West Coast coal)	Lower Cretaceo-Tertiary and Lower Greensand	Danian and Senonian (Upper Cretaceous) (Eocene)	Possibly in Queensland—*e.g.*, Flinders Range	Lower or Middle Cretaceous (?).
Mataura and Putataka ..	Upper and Middle Jurassic	Neocomian and Tithonian, also Middle Jurassic	Clarence River coal-measures, N.S.W. Jerusalem coal-measures, Tasmania	Lower Jurassic. Lower Jurassic (?).
Catlins and Bastion ..	Liassic	..	Unknown	..
Otapiri .. .. .. Wairoa and Oreti	Rhaetic and Lower Triassic	Noric and Carnic .. .. (Upper Triassic)	Wianamatta and Hawkesbury series, N.S.W.	Rhaetic or Upper Triassic. Lower Triassic (?).
Kaihiku	Permian	Base of the Upper Triassic ..	Newcastle coal-measures ..	Permian.
Maitai limestones, &c. ..	Lower Carboniferous ..	Permian or Permo-Carboniferous	Hobart, Tasmania .. Gympie, Queensland .. Port Stephens, N.S.W. ..	Permian or Permo-Carboniferous. Lower Carboniferous and Permo-Carboniferous. Lower Carboniferous.
Reefton	Lower Devonian	Silurian	Murrumbidgee, N.S.W. .. Carcoar and Belubela, N.S.W.	Middle Devonian and Silurian. Silurian.
Baton River	Silurian	Silurian	Yass beds, N.S.W. .. Gordon River, Tasmania ..	Upper Silurian. Lower Silurian.
Graptolitic slates	..	Lower Ordovician ..	Auriferous slates, Victoria ..	Lower Ordovician.

and the Chatham Islands were the remnants of a large continent, formerly extending far to the east, which must have been connected in the Temperate Zone with South America, but there was no evidence of its having been connected with Australia during Tertiary times. The Jurassic flora he recognized as occurring also in Australia, while Deslongchamps (1864) had shown that the Triassic fauna of New Zealand had representatives in that of New Caledonia. The "Lower Carboniferous" beds appear "to have been common to Australia and New Zealand, and to have been deposited in both areas under the same physical conditions, and within a common biological province" (Hector). Haast (1879) repeated Hochstetter's conception of the Southern Alps, held that the sedimentary rocks to the east of the gneissic core of this range were derived in Palaeozoic times from a large continent lying east of New Zealand, of which the Chatham Islands form a remnant, and agreed that New Zealand became a string of islands in Cretaceous and Tertiary times. Hector (1885), however, dissented from Hochstetter's conception of the Southern Alps, and mapped them as synclinal, with a gneissic western margin, followed by Permian rocks on either side of a Mesozoic central zone. Hutton (1885) also concurred with Hochstetter's interpretation of the structure of the New Zealand Alps, but, comparing the manganese-bearing bands in the Maitai system with modern deep-sea deposits, he was led to infer very deep depression during the Carboniferous period. He further noted the resemblance between the graptolites of Australia and New Zealand.

Suess (1888) summarized in the following order the sequence of rock-formations observed in passing eastward from the desert of Western Australia, the depressed zone of Lake Eyre and Spencer Gulf, the Flinders, Mount Lofty, Barrier, and Grey Ranges, and the alternating members of the Australian cordillera. For a long distance the farther extension of the continent is now concealed by the sea, but beyond it, in New Zealand, the Mesozoic series is completed, and with this completion we reach the great ranges and at the same time a region of much more recent folding. "All the chains from the Flinders to the Australian cordillera, including the longer of the two syntactic mountain-segments of New Zealand, must equally be regarded as constructed on a common plan."

Stephens (1889), from an Australian standpoint, made a second interesting correlation of Australian and New Zealand strata. The Australian Carboniferous *Lepidodendron* beds he places by the Devonian (?) Te Anau breccias, and following a break, which is not now recognized as existing here, the greywacke and fossiliferous Maitai limestone are grouped with the Permo-Carboniferous coal-measures and marine beds in Australia. Following another break, the Kaihiku series is grouped not in the Permian, where Hector placed it, but with the Triassic Narrabeen beds, the lower part of the Hawkesbury series. In correlating the overlying Oreti beds with the Triassic Hawkesbury sandstone Stephens was obviously embarrassed by Hector's statements that they show evidence of glacial action and of the presence of *Glossopteris*, both of which are no longer accepted. The succeeding Otapiri-Wairoa beds, which Hector rightly considered Triassic, are grouped with the Upper Clarence beds, which are now known to be Jurassic, and the "Lower Jurassic" Mataura series is grouped with the Rhaetic Wianamatta beds of the Sydney district. Stephens further held that the Tasman Sea persisted throughout these epochs, that eastern Australia and New Zealand were independent groups of islands, both united with Antarctica by emergence during Permo-Carboniferous times, and

connected with Asia by temporary land-bridges during Lower Triassic times (" when *Hatteria* entered New Zealand ").

Professor David (1893) further summarized the pre-Mesozoic geological history of Australasia. He inferred the proximity of land in various regions and periods, but did not offer palaeogeographic charts. Thus he stated that the land which must have supplied the detritus of which the New Zealand Silurian rocks were formed must have existed near the present west coast, but has since been removed by denudation. Portion of it may possibly be represented by the crystalline schists of Otago, but it may be doubted whether there was any land at all within the present area of New Zealand before the commencement of the Mesozoic period, when, for the first time, coarse conglomerates and a land-flora made their appearance.

During the next decade evidence was accumulating which indicated the former extension of Australia to the east and south of its present limits. The former eastward extension, originally deduced by Clarke (1878) from the abundance of the epicontinental Mesozoic deposits and absence of Tertiary marine rocks near the present eastern shore-line, was confirmed by the discovery that there frequently occurs current-bedding in the Newcastle coal-measures, which indicates their deposition by currents flowing towards the west (see David, 1907A). The southward extension, which had been first suggested by Tate's (1879) announcement that the glacial beds near Adelaide contained erratics which appeared to have come from the south, was confirmed when in 1895 it was shown that the most abundant of the recognizable types were derived from near the mouth of the Murray River, fifty miles to the south of their present position. At the same time the glaciation was proved to be pre-Miocene, and was referred to the Cretaceous by Brown, and to the Permo-Carboniferous by Howchin and David, who collaborated with Tate (1895). Further evidence was obtained that the supposedly contemporaneous ice-sheet in Victoria and Tasmania moved to the north-north-east, and that a large elevated land area must have existed to the south-west of the present limits of the three States mentioned.

Hutton (1900, pp. 180–81) again summarized the geological history of New Zealand, in effect saying that of the early Palaeozoic era in this region we know but little; but towards the close of the Devonian period land certainly existed, though its outlines are uncertain. It subsided beneath the sea during Carboniferous times, but subsequently was raised so that in Permian times, after folding had taken place, New Zealand lay near the shore of a continent stretching away towards Tasmania and Australia, to which perhaps it was joined. He concurred with Stephens (1889) in recognizing the fossils of the Maitai series as of Australian Permo-Carboniferous types. Middle Jurassic orogeny was believed by him to have been accompanied by the subsidence of the crust with the formation of the Tasman Sea, though leaving a broad strip of land west of the Southern Alps, which extended northwards to New Caledonia and New Guinea. This connection he believed was broken in the Upper Cretaceous movement of crust-subsidence, and was not renewed in the early Tertiary emergence, with the discussion of which this paper is not concerned.

Lemoine (1906), discussing the former limits of Gondwanaland, considered that it extended across Australia and the Tasman Sea, and that along its northern and eastern shores there migrated the Tethyan forms

from India, through the Malayan region, to New Guinea, New Caledonia, and New Zealand. The gneissic rocks of western Otago were considered as being a fragment of this old and largely subsided continent. Fraser and Adams (1907), while remarking on the difficulty of determining whether the sediment forming the Mesozoic greywackes of New Zealand was derived from the west or east, inclined to the latter alternative (at least for the Coromandel region), but Morgan (1908) supported the former view (as regards the West Coast region), citing, but not committing himself to, Lemoine's opinion. He was opposed, however, to the hypothesis of the anticlinal structure of the Southern Alps, declaring that the rocks forming the western slopes are portions of an older chain striking to the north-west, and separated by overthrust faults and a zone of granitic intrusions from the newer Alpine chain.

Arldt (1907, p. 456) recognized the greater part of Australia as a portion of an Archaean massif, a fragment of Gondwanaland, adding that this "appears from the Carboniferous to the beginning of the Tertiary to have had an important extension to the east, even to the margin of the inner island arc of Melanesia, including the Fiji Islands, Tonga Islands, and New Zealand. Obviously these regions were repeatedly flooded over by the sea. On the other hand, the sea had very early appeared thrusting in between Tasmania and New Zealand, existing here during the Jurassic, but probably at various earlier periods also."

Suess's (1908) last volume contained a modification of his earlier discussion of the structure of Australasia. He now recognized three island arcs about Australia. The first comprised New Guinea, New Caledonia, and North Auckland Peninsula, with the New Hebrides, Solomons, and Loyalty Islands as an outer zone. The second arc was a group of coral atolls running north-westwards from Fiji (a rather unsatisfactory grouping); and the third arc ran from Tonga, through the Kermadec Islands, into New Zealand. "The arcs . . . seem to whirl towards the bifurcation of northern New Zealand. . . . At the same time there are many doubtful points. First among these is the question whether the Australian cordillera along the recent down-break on the eastern coast may be recognized as an inner arc. If so, the whole structure would be concentric about an ancient vertex [or nucleus]. But the manner in which the cordillera is continued across Torres Strait scarcely favours that view. [Various conjectures may be made] . . . but in the hope of solving our problems we create new ones."

Gregory (1908) adopted Suess's comparison of the structure of South America and Australia, but took the section across the former through Brazil, instead of the northern Argentine as did Suess, claiming as the counterpart of the Thompson Trough the comparatively small depression (Lake Titicaca) between the eastern cordilleras of South America and the main range. Marshall (1909) urged the close relationship between Tonga and the North Island of New Zealand, drawing attention to the submarine ridge connecting them (Suess's third arc), adding that it was not unreasonable to regard it as an anticline, and the adjacent trough as a syncline (in which crust-movement is still in progress: Angenheister, 1921). This was supported by Speight (1910) in a paper drawing attention to the existence of continental rock (hornblende-granite) beneath the volcanic accumulations (andesite-lavas and tuffs) of the Kermadec Islands, rocks which are closely analogous to those of New Zealand. A useful summary of the problem of ancient land-extensions in the Pacific is given in this

paper, and in a later one by Marshall (1912). The investigations of Speight (1909) and Marshall (1909) in the subantarctic islands adjacent to New Zealand had led to the discovery of continental (plutonic) rocks therein, suggesting a former extension of New Zealand to these islands, which may have been continued till it united with Antarctica (itself a fractured continent), as the investigations of biologists have indicated.

Park (1910) supported Lemoine's view of the relation of New Zealand to Gondwanaland, declaring that "the Palaeozoic areas in Nelson, Westland, and Otago are merely the remnants of the fringe of the submerged Indo-African continent which appears to have existed up till near the close of the Secondary period." Professor Gregory (1910) was equally emphatic concerning the former unity of Australia and New Zealand. "Australia," he said, "is essentially a fragment of a great plateau-land of Archaean rocks. It consists in the main of an Archaean coign which still occupies nearly the whole of the western half of the continent, outcrops in north-eastern Queensland, forms the foundation of southern New South Wales, and is exposed in western Victoria and Tasmania, and in the western flanks of the Alps of New Zealand. These areas of Archaean rocks were doubtless once continuous, but they have become separated by the foundering of the Coral Sea, and of a band from the Gulf of Carpentaria to the lower basin of the Murray. The breaking-up of the old Archaean foundation began in Cambrian and Ordovician times . . ." These remarks prefaced a short outline of the palaeogeographic evolution of Australia. It might be remarked, however, that the Archaean age of the basement schists (to which might have been added those of New Guinea, the Louisades, and New Caledonia) cannot be considered as proved in all cases. Thus Browne (1914) has adduced evidence of the Ordovician age of the schists in southern New South Wales, and a like age for those of western New Zealand seems not improbable (*cf.* Benson, 1921).

Marshall (1911) pointed out that the comparison of the lithology of the Mesozoic rocks on the east and west of New Zealand did not give any clear indication of the direction from which the detritus forming them had been derived. He recognized the New Zealand - Tonga line as the boundary of the south-western Pacific, but, omitting all of Suess's second Australian arc except Fiji—in which Woolnough (1903, 1907) had found a continental basement of granite and slates with a north-north-east strike—Marshall drew the continuation of the margin of the Pacific along the outer zone of Suess's first Australian arc from the New Hebrides to New Britain, a palaeogeographic scheme for which there is zoogeographical support (Hedley, 1899).

In the same year Professor David (1911) discussed the structure of Australia and its gradual growth. His map illustrates a remarkable bending of the trend-lines about a Western Australian nucleus, being meridional in the south-eastern region, bending to the north-north-west in the centre of New South Wales, to the north-west in Queensland, and to the west in the ranges of central Australia and the Northen Territory. This simple scheme is complicated by the presence of a secondary nucleus or cross-folding in the Kimberley region (W.A.), and by a north-easterly branch of the virgation in South Australia, which strikes through western New South Wales and Queensland into the central portion of the coastal ranges of Queensland near Townsville. Briefly summarizing the geography of the past, he drew attention to the collapse and subsidence in early Mesozoic times of the collecting-ground of the great Permo-Carboniferous glaciers

south-west of Tasmania, Victoria, and South Australia, and to the foundering of the eastern extension of Queensland in late Tertiary times, when "nearly the whole of the eastern watershed of the old Divide to the east of Cairns was sunk beneath the sea." He recognized that New Guinea was a lately folded region, where Cretaceous and even Tertiary rocks are highly disturbed, and that even in Australia tectonic movements are newer as New Guinea is approached. There is need for "a vastly extended series of observations both on land and sea before any satisfactory theory can be advanced as to the plan upon which this island-continent has been built."

Jensen (1911), acknowledging his indebtedness to Professor David's teaching and discussions, concluded that the Australian "continent moved in an easterly direction throughout the Palaeozoic, and by the end of the Permo-Carboniferous had captured more than the whole of the present continent, including many deep-ocean parts. . . . The sediments of one geological period became raised into a marginal buttress of mountain-ranges in the next geological period, the continent advancing a few hundred miles in the direction of the former sea in each geological period." He held that the dominant folding-force came in each period from the sea towards the land.*

Professor David (1914) again summarized the geology of Australia, and also that of Papua, and drew attention (David, 1914A) to the eastward movement of the basins of deposition of sediments in New South Wales, and of the axes of folding and of plutonic intrusions, in the three main Palaeozoic epochs of orogeny recognized by him.

Morgan (1915) was quite uncertain of the position of the land to which New Zealand formed the foreshore or continental shelf in Mesozoic times. As a result of Arber's declaration concerning the absence of *Glossopteris* from New Zealand he "regretfully dismissed" the idea that the continent lay to the west and was indeed the margin of Gondwanaland, though in Seward's (1914) opinion it was not yet necessary to do so. (See footnote, p. 41.)

Andrews (1916), while recognizing the easterly growth of Australia from the western gneissic massif (obviously only the eastern extremity of a still larger continental area), urged that the successive marginal foldings were due to the action of centrifugally (not centripetally) directed forces. His view is thus more or less in accordance with Suess's conception of the growth of the Asiatic continent and his suggestion in regard to Australasia, rather than that advanced by Hobbs (1914), which had been foreshadowed in regard to Australia by Professor David and Dr. Jensen. Andrews, moreover, suggested that New Guinea, New Caledonia, and New Zealand (Suess's first Australian arc) should be considered as distinct units, New

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* In regard to this, reference should be made to Oldham's (1921) comment: "The question of the direction from which the pressure came to which movement is attributed . . . involves a widespread fallacy that pressure can be one-sided. It permeates the great work of Suess, in which we find repeated reference to earth-waves advancing against resistant blocks." In the conceptions put forward by Oldham the word "overthrust" loses its old meaning, and may perhaps be replaced by the more closely applicable term "under-crawl." Oldham continues, "It may be convenient, however, to accept the common usage, incorrect though it be, when referring to the cause from which the displacements are due, so long as the language is understood to be merely descriptive." This criticism seems to go far to reconcile the divergence of statement in the views of David, Andrews, and Jensen.

Guinea having apparently grown from north-east to south-west, and New Zealand from south-west to north-east, though these areas are situated peripherally in regard to the Australian nucleus, and were affected in a measure by the same tectonic forces. In a later paper Andrews (1922) states that "New Guinea, the Solomons, New Caledonia, and New Zealand form the base of a great island knot which has its north-eastern extremity in Samoa. The individual island loops of this knot appear to be separated from each other and from the central portion, but are continental and confluent at the southern and western extremities. The knot itself would appear to arise as the result of the mutual interference of the Tethyan and Pacific controls." Schuchert (1916) declared that eastern Australia and New Zealand were separate geosynclines in Palaeozoic times, and that the latter remained such during Mesozoic, and (he unexpectedly adds) during Cainozoic times also. The area now occupied by the Tasman Sea he considers to have been mostly land at the commencement of Palaeozoic times, but that the sea steadily encroached thereon, advancing northwards, the connecting ridge between New Guinea and New Caledonia - New Zealand having been first sundered during Triassic times, when, by a curious error, he believes the last two regions to have been entirely land areas.

Wilckens (1917), acutely summarizing many contradictory accounts, suggested a comparison between the structure of the European Alps and those of New Zealand, which appeared to him as probably asymmetric and thrust to the south-west and west against the gneissic massifs of western Southland and Fiordland, and to the north-west against a foreland of folded Palaeozoic rocks, now mostly foundered beneath the Tasman Sea, except for the area forming the mountains of the north-western portion of the South Island, thus supporting part of Morgan's (1908) conception of the structure of the Southern Alps. A somewhat similar hypothesis was independently formulated by the writer (Benson, 1921).

Walkom's (1918) careful discussion concerns Mesozoic times chiefly. He conceives that at the commencement of this period a single undivided continental mass extended throughout Australasia, New Guinea, and Fiji, and that its fragmentation with permanent enlargement of the Pacific Ocean commenced at this time. Epicontinental Triassic rocks were deposited in New Zealand and New Caledonia, and a temporary northward extension of the southern ocean formed a gulf extending towards Sydney. The sea regressed somewhat in Jurassic times, the above-mentioned gulf disappearing, and the great subsidences with the formation of the Tasman Sea apparently are considered to have been somewhat later. This wide extent of land, which is assumed to have extended east of the present coast-line of Australia, has recently been named "Tasmantis," the term being defined as indicating "those portions of New South Wales and Queensland cut off from the remaining parts of Australia during the Carboniferous period [which] were parts of a separate land area which existed to the east of the Australian continent at least as far back as the beginning of the Devonian period, and probably as far as the beginning of the Palaeozoic era. This land became permanently united to the mainland of Australia towards the close of the Carboniferous period" (David and Süssmilch, 1919). In this conception of an important geosyncline separating, until the close of Carboniferous times, the Australian nucleus from that now subsided beneath the Tasman Sea we have a marked accord with Schuchert's (1916) suggestions.

Bartrum (1920) called attention to the widespread occurrence of pebbles of gneissic and plutonic rocks in the Mesozoic and later rocks of the North Island of New Zealand, and supported Park's (1893) inference that an ancient complex of plutonic and metamorphic rocks formed a land-mass near this region during Mesozoic times. The comparison of the work of Piroutet and Trechmann made by the present writer (Benson, 1921) supported the suggestion that the remarkable community of characters of the successive Mesozoic marine faunas of New Zealand and New Caledonia was such as to indicate that these regions were then part of a continuous coast-line. Farther north the former continuity of the islands of the Louisades Archipelago with the central chain of Papua as indicated by Clarke (1878) is confirmed by Stanley's (1921) researches.

The Tectonic Relationships of Australasia and Antarctica.

We may here pass on to consider the geological hypotheses of a former connection between Australasia and Antarctica, but omit, as in the above, the discussion of zoogeographic and phytogeographic evidence. The problem has been treated briefly by Mawson (1911) and Gregory (1912), and in more detail by David (1914B). All the region of South Victoria Land extending as far as Adelie Land appears to consist of an ancient gneissic or metamorphic complex, with some early Palaeozoic beds overlain by horizontally bedded Upper Palaeozoic and possibly Mesozoic sandstones invaded by immense sills of dolerite. The structure is thus somewhat analogous with the structure of Tasmania on the one hand, and of Brazil on the other. The Andean zone of folded mountains, with its eastern continental foreland and western zone of fragments of an ancient complex, appears to be represented in the Antarctandes, running through Graham's Land between the western fringe of islands and the eastern area of continental rocks for the most part foundered beneath Weddell Sea. The question as to the position of the representatives of the Antarctandes on the Australasian sector of the Antarctic has been variously answered. Though emphasizing the complete divergence in structure between the Antarctandes and the very continuous though narrow horst, the Royal Society Range, west of Ross Sea, Professor David supports Amundsen's suggestion that the latter may represent the continuation of the Antarctandes, and be in turn continued into southern New Zealand, the fractures bounding them being perhaps part of the same system as the Te Anau line of fracture. "Tectonically," he writes, "but not as regards folding, the evidence seems favourable for considering the great horst of South Victoria Land, in spite of the dissimilarity of its eruptive as well as of many of its sedimentary rocks with those of the American Andes, to be partly related to that great range, and possibly its fractures are not only continuous with those of the South American Andes on the one hand, but also with those of the subantarctic islands, like the faulted area of Campbell Island, and with those of the Alps of New Zealand on the other." The same suggestion had previously been made by Arldt (1907, pp. 497–98), who had, moreover, extended the range through New Zealand to incorporate the Kermadecs, Tonga, and Fiji.

Mawson (1911), while supporting the above view as the most probable, put forward an alternative conception. The Antarctandes of Graham's Land may continue towards King Edward VII Land as a folded range, and be separated by a comparatively low zone from the

mighty ranges of South Victoria Land. "The dynamics which have effected the land-building of Tasmania and eastern Australia correspond more strictly with those whose sequence is illustrated in the plateau-massif of South Victoria Land; on the other hand, New Zealand and the archipelagoes of the adjacent Pacific Ocean are illustrations of the Andean tectonics in the Australasian region." With this second view Professor Gregory (1912) is in accord. "The information now available," he writes, "shows that South Victoria Land is more similar in structure to eastern Australia than New Zealand. Hence it appears most probable that the continuation of New Zealand and of the primary Pacific coast lies through King Edward VII Land towards Graham's Land." Subsequently Wilckens (1917) declared that the truncated fold-axis of Otago was the continuation of the "Antarctandes" of Graham's Land—the formerly continuous folded margin of the South Pacific Ocean. This view is also adopted by Kober (1921), who suggests, moreover, that an orogenic zone now submerged separates Antarctica from Tasmania and South Africa. This conception is opposed to previous ideas, and is put forward only tentatively, but finds some support in Du Toit's (1920) hypothesis of the conditions of intrusion of the dolerite sills in these three regions.

If we recall the twofold origin of the New Zealand Alps, these diverse views may be reconciled. While, with Gregory and Wilckens, we may consider as most probable the continuation of the axis of late Mesozoic orogeny through the Antarctandes and King Edward VII Land to New Zealand, we may well correlate the Cainozoic block-faultings and crust-fracturings which, crossing obliquely the older structure-lines (Cotton, 1916), have raised the New Zealand Alps as "a concourse of earth-blocks," with the fracturing, elevation, and subsidences that have separated Antarctica from Australasia and New Zealand, isolated the subantarctic islands, and caused the formation of the horst of the Royal Society Range and the trough of Ross Sea. This correlation is the more easy if we accept Henderson's (1917) view that the movements of block-faulting occurred at intervals during the Cainozoic period in New Zealand, which is not in any way incompatible with the trend of physiographic evidence in eastern Australia, as interpreted by Andrews (1910).

Professor David's (1914b) map of the trend-lines of the circumpolar region supports the suggestion that we may take the zone of the Otago schists and New Zealand Alps as representing the continuation from King Edward VII Land of the circumpacific folds. Such a zone would leave on the one side the plutonic rocks of the Campbell, Auckland, Snares, and Stewart Islands, and of the south-western extremity of New Zealand as representing fragments of the Australasia–South Victoria Land platform, while the schist of the Chatham Islands, and *perhaps* the granitic rocks of Bounty Island,* might be classed as the fragments of ancient lands corresponding with those which along the west coast of South America lie between the Andean zone and the Pacific. This hypothesis would not, therefore, attach much significance to Hector's (1870) comparison of the mica-schists of Chatham Islands and Central Otago. An alternative and perhaps preferable explanation would regard the crystalline rocks at least of the Chatham and Bounty Islands, together with the schists of Central Otago, as portions of the circumpacific orogenic zone.

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* Speight compares this rock with that of Auckland Island, and believes that these two formed parts of a single massif.

Park (1910) has suggested that the Chatham Island ridge "is the eastern wing of the great synclinal in the trough of which lie the folded Mesozoic rocks that compose the Alpine divide and the parallel ranges of the Dominion lying to the eastward." The importance of the fracture-lines traversing and often limiting the New Zealand area, and their general obliquity to the axes of the Cretaceous folding, have been emphasized by Cotton (1916, 1917) and others. In particular we may note the continuance of the direction of the Tonga–Kermadec trench by the White Island–Tarawera Ruapehu zone of volcanic activity. Indeed, the above-noted seismic activity in the Tongan trench and in the eastern suboceanic slopes of New Zealand (Hogben, 1914) may afford evidence of the continuance at the present day of the conditions that led to the formation of the south-western margin of the Pacific. Marshall's (1911) outline of the margin would bring into accordance with this the seismic activity in the New Hebrides indicated by the Rev. E. F. Pigot's seismometric investigations at Riverview, Sydney.

Turning to the palaeontological evidence of the relationships of Australasia through the Antarctic with South America, we note that Taylor (1914) has recognized close allies of South Australian species of Archaeocyathinae in a limestone from South Victoria Land, and Gordon (1920) has noted the presence of this group of organisms in a limestone dredged from a depth of 1,775 fathoms off the South Orkney Islands. Seward's (1914) recognition of *Glossopteris indica* in the specimens collected by Captain Scott and Dr. Wilson permits us to class Antarctica as part of the congeries of continents known as Gondwanaland, and to infer its close association in Permian times with Australia on the one hand, and on the other with the Falkland Islands and eastern South America, where the same form occurs. Professor David (1914) indicated that "the close affinity of the flora of Graham's Land to that of Australia implies a land connection between Antarctica and Australia in Jurassic or Trias-Jura time." Arber (1917), while declaring that *Glossopteris* was absent from New Zealand, and that therefore the New Zealand area did not in Permian times contain a land-mass connected with Gondwanaland, added that there was in Trias-Jura times so great a community between its flora and that of Australia and Graham's Land as to indicate that all three land areas were intimately connected. With this Walkom (1918) concurred. Woods (1917) showed that some community occurred between the Senonian faunas of New Zealand and South America, but this was emphasized in the papers of Trechmann (1917) and Wilckens (1920), the latter declaring that South America, Antarctica, and New Zealand formed at that period part of the continuous southern coast of the Pacific Ocean.

We may here note without discussion Wegener's (1922) remarkable hypothesis. In a sketch-map of the Carboniferous world he shows Antarctica, South America, Africa, peninsular India, and Australia crowded together, while a marginal shallow sea covers the region of New Guinea and New Zealand. This connection, he indicates, was maintained up to the Jurassic times, while that of Australia, Antarctica, and South America persisted until as late as Eocene times. "The general westward movement of the continents is evidenced by many striking features . . . Since the frontal resistance must have a much greater influence for smaller masses than for large, these smaller masses will be left behind in the general westward movement. Thence comes . . . the separation, long ago completed, of the former Australian coastal chain which now forms New Zealand."

THE POSSIBILITY OF DETAILED STRATIGRAPHICAL CORRELATION OF AUSTRALASIAN GEOLOGICAL FORMATIONS.

Before discussing the history of the various geological epochs in Australasia it seems well briefly to consider how far this is or may be determined in detail, for opinion has varied on this point among workers on Australasian fossils. McCoy (1866) believed in "the fact of the specific identity of the marine fauna of the whole world during the most ancient Palaeozoic periods." De Koninck (1877), while recognizing endemic Australian species, supported McCoy by referring also many Australian forms to European species of Silurian, Devonian, or Carboniferous age. The validity of these identifications is, however, often open to grave doubt, and Etheridge (1891) advised that no Australian fossils be referred to European species unless on the clearest possible evidence, and that, moreover, great caution should be exercised "in assimilating our geological subdivisions strictly with those of the Old World." Johnston (1887) argued that fossil plants can afford *no* satisfactory clue to the correlations of strata with those of a distant region: "All that palaeontology can prove is local order of succession." Tate (1901), while arguing against homotaxy, inclined to the extreme view that each of the "permanent" continents had originally the same primitive fauna, the approximately parallel and *pari passu* evolution of which produced the present provincially specialized yet broadly similar faunas, though exact intercontinental age-correlations were impossible. Hall (1902A) gave a general support to the latter statement, concluding that "It is possible in most cases to refer our Australian strata definitely to one or other of the great European periods, but it is not always so. Terms such as 'Permo-Carboniferous' and 'Trias-Jura' express a mingling of faunas representing two distinct northern systems, and are not cloaks to hide our ignorance. This mingling is not necessarily due to the Australian systems being intermediate in age, and being the representative of the great unconformities of the Northern Hemisphere, but probably in a great part follows from differential rates of migration and points to a northern or southern place of origin of the transgressing forms." Later (1909) he remarked, "At present we are unable to subdivide the Upper Ordovician of Australia. It is quite unsafe to apply the facts of distribution of Europe and America to our rocks, in spite of definite opinions to the contrary." Somewhat similar views have been current in New Zealand. Thus Hector (1886) and Park (1910) held there was "a curious commingling of Permo-Carboniferous and Upper Triassic forms"; while Marshall (1912) emphasizes the association of the Jurassic forms *Trigonia* and *Gryphaea* with an apparently Triassic assemblage. As recently as 1919 Etheridge, in describing the Cambrian trilobites of Australia, purposely refrains from adopting the terms "Lower" and "Upper" Cambrian to indicate their horizon, "believing that we know too little as yet of the Cambrian strata throughout Australia and Tasmania to warrant the use of stratigraphical subdivisions employed either in Europe or America," and therefore he records merely "the opinion of others." Dun also (1919) cites several instances of the apparent mingling of forms—the occurrence of Jurassic and Cretaceous types in the Rolling Downs beds, the wide range (Carboniferous to Triassic, *fide* Woodward, 1908) of affinities of the fossil fish in the probably late Triassic shales near Sydney, &c.—reaching the conclusion that "in this region the European standard of palaeontology cannot be followed."

But, while we must not be unmindful of the difficulties, it may be questioned whether the emphasis placed on them has not unduly discouraged

workers from attempting careful zonal collecting and investigation of faunas, more fully to test the possibility of detailed interpretations of the Australian geological record. Such recent work as has been done seems full of promise. Walcott's (1916) comparison of the Lower Cambrian fauna of Australia with that of eastern Asia, and Keble's (1920) elaboration of Hall's graptolite zoning of the Lower Ordovician, are cases in point. Ruedemann (1904) has indicated that the zonal sequence of the graptolite fauna of New York in so far as it departs from that established in Europe approximates to that of Victoria. Further, though, as Schuchert (1910) has pointed out, the older generalized determinations of fossils and their reference to cosmopolitan species are not of great value to the modern palaeogeographers, and are usually much modified on revision, the facts, such as they stand at present, in regard to the Devonian period are at least strongly suggestive of many interesting conclusions. The need for the compound term "Siluro-Devonian" has vanished. So, too, the term "Permo-Carboniferous" is gradually succumbing to the detailed inquiries of Professor David and his associates; while the term "Trias-Jura" has been robbed of the significance Hall attached to it (as indicating a real admixture of forms) by the important work of Trechmann and Wilckens on the Triassic marine rocks of New Zealand, of Piroutet on those of New Caledonia, of Arber on the Mesozoic flora of New Zealand, and of Walkom on that of Queensland ("the most significant publication of the year's general palaeobotany"),* which have shown that when the fossils are accurately determined on modern lines, and the erroneous identifications have been eliminated, age-determinations and stratigraphical correlations may be made with considerable precision. So, too, in New Zealand the Cretaceo-Tertiary hypothesis seems to have been overthrown, and the work of Woods, Wilckens, Trechmann, Chapman, and Marshall has indicated the presence of an Albian fauna, and much more definitely a Senonian fauna also, quite distinct from the Tertiary fauna. It must nevertheless be recognized that the provincial character of Australasian stratigraphy has been established for some periods, and the correlation of stratigraphical subdivisions, with extra-Australasian strata, is still very difficult in the Upper Ordovician rocks, the "Permo-Carboniferous" and "Lower Cretaceous"; while in the Cainozoic the local specialization of the stratigraphical and palaeontological record seems to prevent as yet even the detailed comparisons of strata in Australia and New Zealand.

We may nevertheless keep well in mind the words of one under whom the writer was privileged to study: "In the case of stratigraphical geology, if we were compelled to be content with the correlation of systems only, and were unable to ascertain which of the smaller series or stages were contemporaneous, but could only speak of these as homotaxial, we should be in much the same position as the would-be antiquary who was content to consider objects formed by the Romans as contemporaneous with those of mediaeval times. Let me urge my countrymen to continue to study the minute subdivisions of the strata, lest they be left behind by the geologists of other countries to whom the necessity of this kind of study is apparent, and who are carrying it on with great success" (Marr, 1896).

In the present paper the writer, who can make no claim to expert palaeontological knowledge, has considered merely the literature as it now stands, without attempting to revise the data or to discuss pros and cons,

* M. C. Stopes, *Science Progress*, vol. 14, p. 347, 1919.

and has drawn from it such tentative inferences as seem justifiable at the present time, in the hope that such a summary may help to direct attention to this broad aspect of geology. The immediate need is for careful revision of much of the palaeontological data, the more exact determination in the field of the horizon or stratigraphical range of the various fossils, and the palaeogeographic consideration of the lithology of the rocks which contain them.

THE GEOLOGICAL HISTORY OF AUSTRALASIA.

The foundation of the Australasian region is indicated as far as possible by map 1, which shows the areas of exposed definitely pre-Cambrian rocks, the probably late pre-Cambrian Nullagine rocks of Western Australia and the possibly late pre-Cambrian or so-called "Lower Cambrian" of South

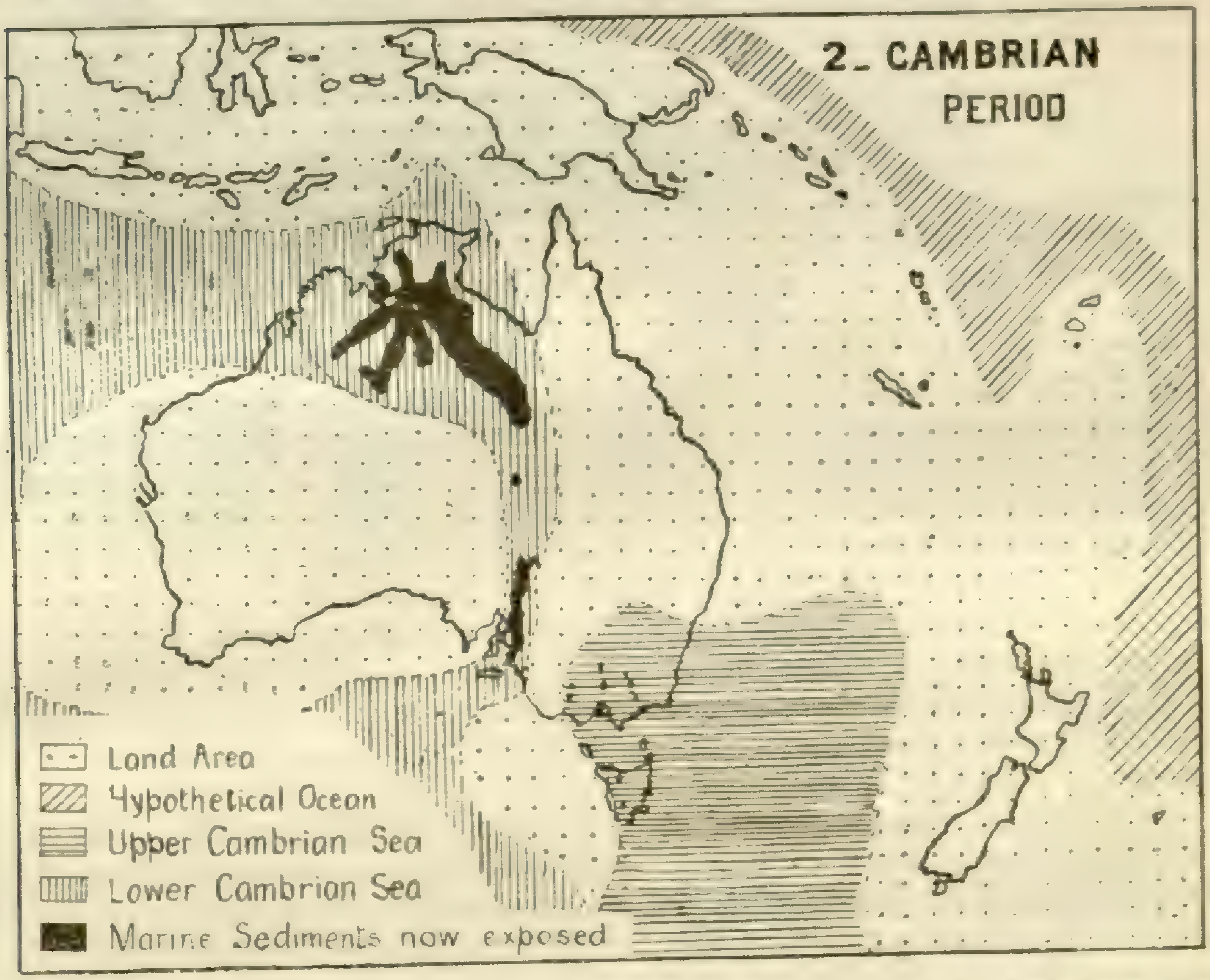
Australia, the metamorphic complexes of uncertain age, and the post-Cambrian granites and diorites. In the palaeogeographic maps 2–11 there is inevitably great uncertainty concerning the former distribution of sea and land in the vast and now submerged areas east of Australia, and the outlines are merely suggestions which accord with some of the facts of distribution of fossils or rock-types, and are not opposed by any other facts known to the writer. These do not depart more than seemed desirable from the earlier suggestions of Schuchert for the Palaeozoic times and Walkom for the Mesozoic. The bulk of the literature concerning the particularly intricate region of the Malay Archipelago and New Guinea, especially the fine work of Abenadon, Brouwer, Molengraaff, Verbeek, Wanner, and Wichmann, has not been accessible to the writer, and the sketches are based on such literature as is cited herein.* Since the oldest rocks in this region of which the age is definitely determinable are Permian, the palaeogeography of earlier periods in this region is purely speculative. Under the most favourable circumstances the accurate palaeogeographic charting of this region would be wellnigh impossible. We have but to recall Professor David's (1914) comparison of the relation of New Guinea to Australia with that of the Himalayas to India, or Brouwer's recent summary (1921) indicating the alpine character of the overthrust-folding of the eastern Malayan islands, to realize that the region must have been formed as a series of anticlines in a broad geosynclinal zone, in which, as in its prototype, extensive and frequent geographic changes must have occurred during successive orogenic movements. The same was probably the case in the Solomon Islands and New Hebrides where "cordilleran" rocks have been found.

Cambrian.

In the Cambrian period a continental mass stretched from the west of the present coast of Australia at least to the western borders of the four eastern States. This continuous mass was, however, broken by a broad syncline which extended meridionally throughout the central zone of the present area of South Australia, flanked by the ancient complex of Eyre Peninsula to the west and that of Broken Hill and Tasmania to the east. This synclinal zone seems to have continued from pre-Cambrian times. In the Adelaide region, unconformably on a probably Algonkian complex of schists invaded by diorites and syenites, there is a thick series of sediments, basal grits, phyllites with interstratified limestones and quartzites followed by thick tillites, banded possibly "varve"-like (Tapley's Hill) shales, and further limestones and shales. All of these Howchin (1918) considers of Lower Cambrian age, believing them to be conformably overlain by the Archaeocyathinae limestones, which he considers of Upper (or possibly Middle) Cambrian Age, and shows to transgress beyond the limits of the sediments mentioned, and to lie on basal grits following directly on the ancient crystalline complex at Ardrossan, in Yorke's Penisula, directly west of Adelaide (Howchin, 1918A). Schuchert (1914) holds that the tillites, &c., are pre-Cambrian, and that a disconformity must exist between these and the Archaeocyathinae limestones, which he considers to be definitely Lower Cambrian. This last is the view of Walcott (1916), who has examined

* While this paper was in the press access was obtained to the valuable summaries of the geology of the eastern and western portions of the Malay Archipelago by Brouwer (1919) and Van Es (1919) respectively. Time has not permitted a complete study of these, but some data therefrom are incorporated below.

a representative collection of fossils, and it must therefore be considered the more probable.* The fossiliferous limestone makes a large reef-like mass at Blinman, four hundred miles north of Adelaide, and also occurs to the south of that city. Here flourished some thirty-seven species of Archaeocyathinae, *Kutorgina*, *Nisusia*, *Micromitra*, *Eoorthis*, *Huenella*, *Obolella*, *Stenotheca*, *Ophileta*, *Hyolithes*, *Salterella*, *Olenellus ?*, *Redlichia*, and *Ptychoparia* (Etheridge, 1890, 1919; Taylor, 1910; Walcott, 1916; Howchin, 1918). No fossils are found in the overlying sandstones, the current-bedding and red colour of which suggest that they were laid down as the Lower Cambrian sea regressed from this South Australian trough.



Besides this transgression and regression of the sea into and from the South Australian trough there was a far more extensive flooding of the northern portion of the Australian continental massif. This appears to have been somewhat irregular in the commencement of Cambrian times, and there was laid down a very extensive series of conglomerates, grits, and sandstones, with some shales, followed by limestones now more or less dolomitic and silicified. This generally slightly undulating but locally strongly warped series extends from the Kimberley district, in the northern part of Western Australia, across the Northern Territory into western Queensland. The sediments contain *Salterella*, *Agnostus*, *Microdiscus*, *Ptychoparia*, and a *Redlichia* formerly described as *Olenellus ? forresti* (Etheridge, 1895, 1897, 1919; Woolnough, 1912; Basedow, 1914-15; Jensen, 1915; Maitland, 1919). There is no evidence to indicate whether the sea extended farther east than the Barkly Tableland, but it was

* Compare also the relationship of the Lower Cambrian rocks on the Yangtse-kiang to the underlying glacial beds, which are "very probably" of Algonkian age (Walcott, 1914).

probably connected with that in the South Australian trough. The possibility that this sea extended south-westwards to the Macdonnell Ranges was suggested by Howchin (1914) on account of the occurrence therein of *Cryptozoön* in dolomitic limestones which according to Chewings lie unconformably beneath fossiliferous Ordovician rocks.

In regard to the origin of this fauna the evidence is as yet rather fragmentary; indeed, Reed (1910) and Haug (1911) considered that no palaeogeographical conclusions of much value could be based on it. Since they wrote, however, Walcott (1913, 1916) has examined representative Australian forms, and made valuable comments on the bearing thereon of the Cambrian faunas of Asia. "The Lower Cambrian Man-t'o *Redlichia* fauna . . . is, so far as known, very distinctive, and confined to the Asiatic continent and Australia. Its transgression over eastern and south-eastern Asia was somewhat later than the transgression in the Siberian area now occupied by the Lena and Yenesei Rivers. . . . The distribution of the *Redlichia* of the *R. noetlingi* form serves to demonstrate that the transgressing Lower Cambrian sea that contained *Redlichia* was confined to eastern and south-eastern China and northern India. The presence of *Redlichia*-like trilobites in southern and western Australia indicates that there was a direct connection between the Punjab Lower Cambrian sea of India and the shallow seas about the Australian area. There is no record pointing to a connection between the Punjab-Man-t'o sea and the Lower Cambrian seas of northern Siberia or western North America." In another sentence, however, he states, "The Siberian fauna is, however, that of the Lower Cambrian of Australia, Sardinia, and North America" (in which Archaeocyathinae are present). According to H. Mansuy's (1912) work, the Lower Cambrian *Redlichia* fauna is present also in Yun-nan. The fact that the Archaeocyathinae are more abundant in South Australia than in any other part of the world may suggest that it was a centre of evolution and dispersion for these forms, but this is not certain.

It was perhaps during the middle part of the Cambrian period (Tilley, 1919) that there occurred these extensive crust-movements and plutonic intrusions which are most strongly indicated along the eastern slopes of the Mount Lofty Ranges, and possibly have affected the region stretching then north-eastward to the western side of the Broken Hill area, though the main orogeny here may have been more ancient. Certainly the coast-line of Australia in Upper Cambrian times ran from western Tasmania into western Victoria, and then probably turned north-east or eastwards. In Tasmania littoral sandstones are found in the Florentine Valley in the centre of the southern half of the island (*Ptychoparia* and *Dikellocephalus* occurring in these), while near Latrobe (Caroline Creek) there is a friable sandstone containing the same genera together with *Leptaena*, *Orthis*, *Raphistoma*, and *Ophileta* (Etheridge, 1882, 1919; Twelvetrees, 1909).

The Upper Cambrian (Heathcotian) rocks of Victoria are more widespread, and were laid down in deeper water and farther from the littoral. They consist of shales and radiolarian cherts with *Protospongia* associated with spilitic lavas and tuffs. Limestone is rarely present. The fossils present include the purely Cambrian forms *Lingulella*, *Acrothele*, *Billingsella*, *Eoorthis*, and *Huenella*, together with those of a more Ordovician aspect, *Leptobolus*, *Herbertella*, *Eostrophomena*, and *Clitambonites*. The trilobites are represented by *Agnostus*, *Dinesus*, *Crepicephalus*, *Notasaphus*, and

Ptychoparia. These beds are strongly folded and followed conformably by Lower Ordovician rocks (Skeats, 1908; Chapman, 1904, 1911, 1918A; Teale, 1920)—indeed, it is very difficult to draw a line of separation between them. Keble (1920) holds that the lower part of the Lancefieldian beds, considered by Hall to belong to the base of the Ordovician series, is in reality Upper Cambrian. It contains *Bryograptus* and *Clonograptus* as the chief fossils, with some *Tetragraptus*, while in the upper part of the same beds *Tetragraptus* and *Didymograptus* are the dominant genera. Chapman (1918A) has noted the presence of *Acrotreta*, usually a Cambrian brachiopod, in both the Heathcotian and lower Lancefieldian beds.

In regard to the source of this fauna little can be said at present. The Upper Cambrian faunas in general were much less provincial than those of Lower Cambrian times, and in particular there was a merging of the North American and Asiatic faunas (Walcott, 1913). It is noteworthy that *Dikellocephalus* is as generally characteristic of the Upper Cambrian of America as is *Olenus* of that of Europe, so that the Australian fauna may thus be less related to the European than to the Asiatic-American fauna.

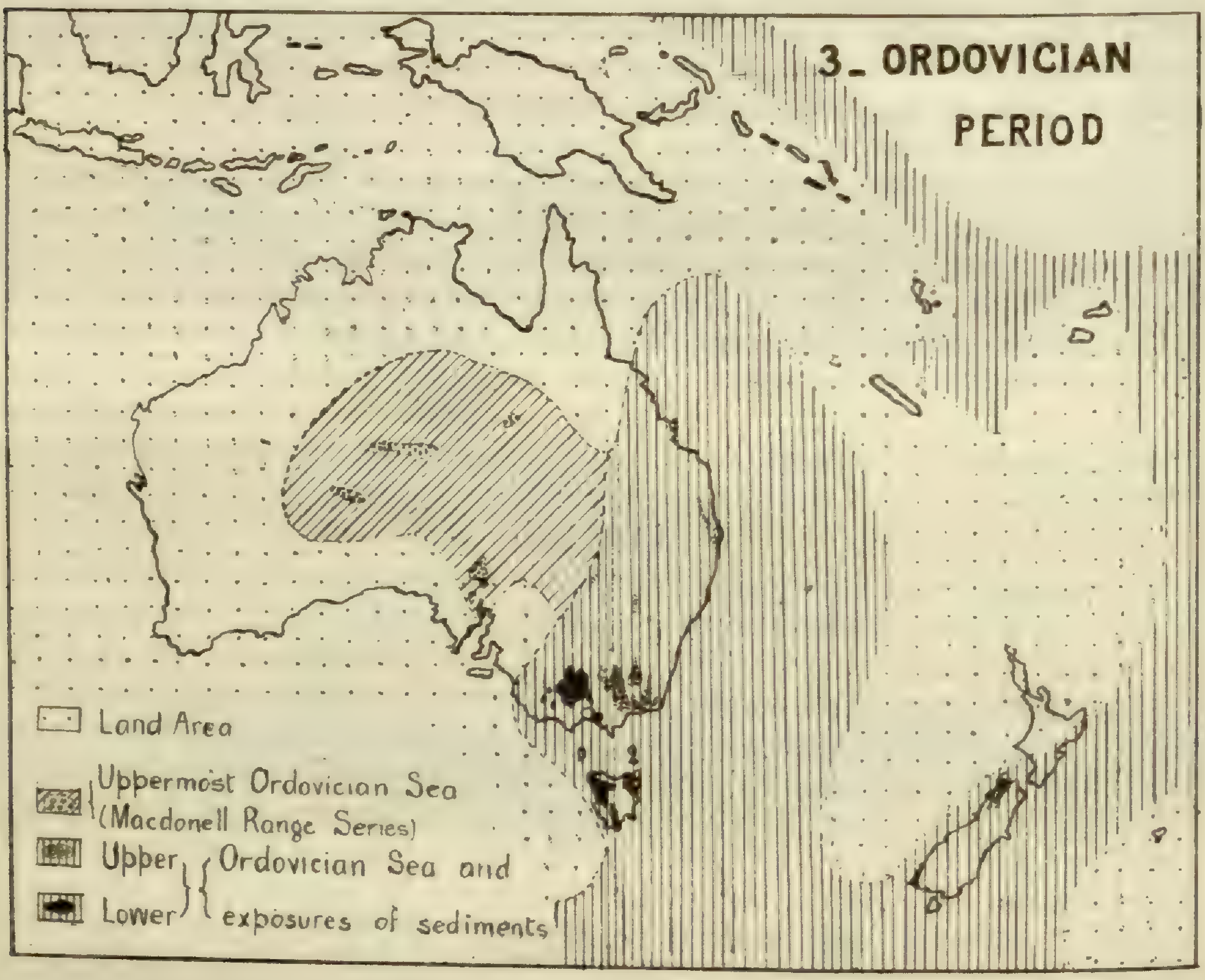
No New Zealand rocks have been proved to be of Cambrian age on definite palaeontological grounds, though if the Upper Cambrian age of the basal Lancefield beds is sustained it is probable that the graptolite slates of Preservation Inlet, in the south-western extremity of the South Island—which Hall (1915) referred to the basal Lancefield beds because of the occurrence of *Bryograptus*, *Clonograptus*, and *Tetragraptus* in them—should also be of Upper Cambrian age. According to Park (1921), an extensive series of unfossiliferous sediments lies stratigraphically beneath these.

Ordovician.

The coastal zone now passed through western Tasmania, Victoria, and New South Wales, bending north-eastwards into Queensland. In Tasmania the littoral deposits were breccias and sandstones and slates with indefinite graptolitic markings (*Callograptus?*). In the Permo-Carboniferous glacial till at Wynyard, in the north-west of the island, erratics presumably derived from these contain *Tetragraptus*, *Phyllograptus*, and *Diplograptus?* as determined by Hall (Twelvetrees, 1907), also *Siphonotreta*, and *Caryocaris* (Chapman, 1907), while farther to the east the unfossiliferous slates of the north-eastern portion of the island may be the off-shore deposits of the same age. Extensive masses of intrusive and effusive keratophyric porphyroids, &c., form the closing members of this series. They run meridionally through the western portion of the island, and these effusive rocks appear to have been in part submarine, in part subaerial. Hills considers them the product of a coastal volcanic zone (private communication*). In Victoria the littoral deposits are scarcely recognizable, but the Lower Ordovician graptolitic slates are well developed in the western half of the highlands of Victoria, being for the most part covered by the Upper Ordovician slates in the eastern half of the highlands. Both upper and lower slates in several regions contain remarkable phosphatic breccias in which wavellite has been found. In New South Wales we may perhaps consider as littoral Ordovician rocks the strongly folded series of conglomerates and sandstones at Cobar merging eastward into more slaty and even cherty

* See also Hills (1921). The writer is greatly indebted to Mr. Hills for furnishing him with a *résumé* of this useful paper in advance of publication.

rocks, which Andrews (1913) considers to be pre-Silurian. These are followed eastwards by a widespread series of graptolitic slates and (rarely) radiolarian cherts, which, however, belong entirely to the Upper Ordovician. In the north-eastern corner and extending thence into Queensland are the very altered phyllitic rocks known as the Brisbane schists, and these, together with some slaty rocks near Rockhampton, contain phosphatic minerals which, in the absence of better evidence, has caused them to be grouped with the Ordovician rocks of Victoria (Dunstan, 1916). The graptolitic Lower Ordovician rocks in Victoria were divided by Hall (1899, 1914) into four major groups, termed, in ascending order, the Lancefieldian, Bendigonian, Castlemainian, and Darriwillian beds respectively. Harris (1916) and Keble (1920) have divided parts of this succession into numerous subzones, the latter finding these to be of considerable economic



significance in the study of the Bendigo region. Characteristic genera of the Lower Ordovician beds are *Clonograptus*, *Bryograptus*, *Tetragraptus*, *Didymograptus*, *Phyllograptus*, and *Loganograptus*. Of these the first two abound in the (possibly Upper Cambrian) lowest portion of the Lancefieldian beds, wherein the second two are subordinate, but the first pair also ascend as high in the series as the Castlemainian beds, which is on a higher horizon than the highest to which they ascend in Europe and America, where *Clonograptus* barely enters the Ordovician formation. The Upper Ordovician faunal succession has not yet been so closely studied and subdivided, but is well exemplified in eastern Victoria—see Whitelaw (1916), Harris and Crawford (1921)—and is the only type of fossiliferous Ordovician rock in New South Wales. Slates, more or less cherty, and jasperoids occasionally radiolarian, occur with andesitic (or spilitic) lava-flows. The chief fossils

are *Protospongia*, *Climacograptus*, *Dicellograptus*, *Dicranograptus*, *Didymograptus*, *Diplograptus*, *Glossograptus*, and *Retiolites*; while *Obolella*, *Hyolithes*, *Trinucleus*, and perhaps *Agnostus* are present (Hall, 1900, 1902, 1909, 1920).

Lower Ordovician rocks form the oldest fossiliferous formations in New Zealand, and consist of greywackes, some limestone, and graptolitic slates apparently merging into mica-schists. In the south-western extremity of New Zealand (Preservation Inlet), originally described by McKay (1896), the slates contain *Clonograptus*, *Bryograptus*, and *Tetragraptus*, for which reason Hall (1915) correlates them with the lowest portion of the Lancefieldian beds in Victoria and considers them of basal Ordovician age, though, as pointed out, it is possible they should be classed as uppermost Cambrian. The slates seem to pass down into mica-schist and these in turn into the so-called "granitic gneiss," a sillimanite-paragneiss which Park (1921) suggests may represent Cambrian sediments, but in such complexes the appearance of superposition and relative degree of metamorphism cannot safely be taken as proving relative age. In the north-west of the South Island of New Zealand the Lower Ordovician rocks are much more widespread, though similar in lithological character (Bell, 1907). The genera present in the fossiliferous rocks are *Bryograptus*, *Dichograptus*, *Didymograptus*, *Loganograptus*, and *Tetragraptus*. The determinations made by Mrs. Shakespear (1908) and Hall (1915) concur in indicating the presence here of two zones belonging to the middle portion of the Lower Ordovician. Recently Professor Park has discovered a further series of graptolitic slates at Cape Providence, twelve miles north-west of the older graptolitic slates at Preservation Inlet. His preliminary determinations of the forms present indicate that they are approximately coeval with those last mentioned in the northern end of the Island, and with the Castlemainian beds of Victoria. (Private communication.)

In regard to the derivation of the Australasian graptolitic fauna, it may be said at once that the forms present are those of the cosmopolitan pelagic types found in Europe, New York, Bolivia, and recently in Peru (Lapworth, 1917), but that in those features in which, according to Hall, the Victorian (and also the New Zealand) zonal succession of forms departs from the European succession it accords with that proved by Ruedemann (1904) to be present in New York. It would appear, therefore, that the conditions obtaining in Upper Cambrian times were not wholly reversed during the Ordovician period.

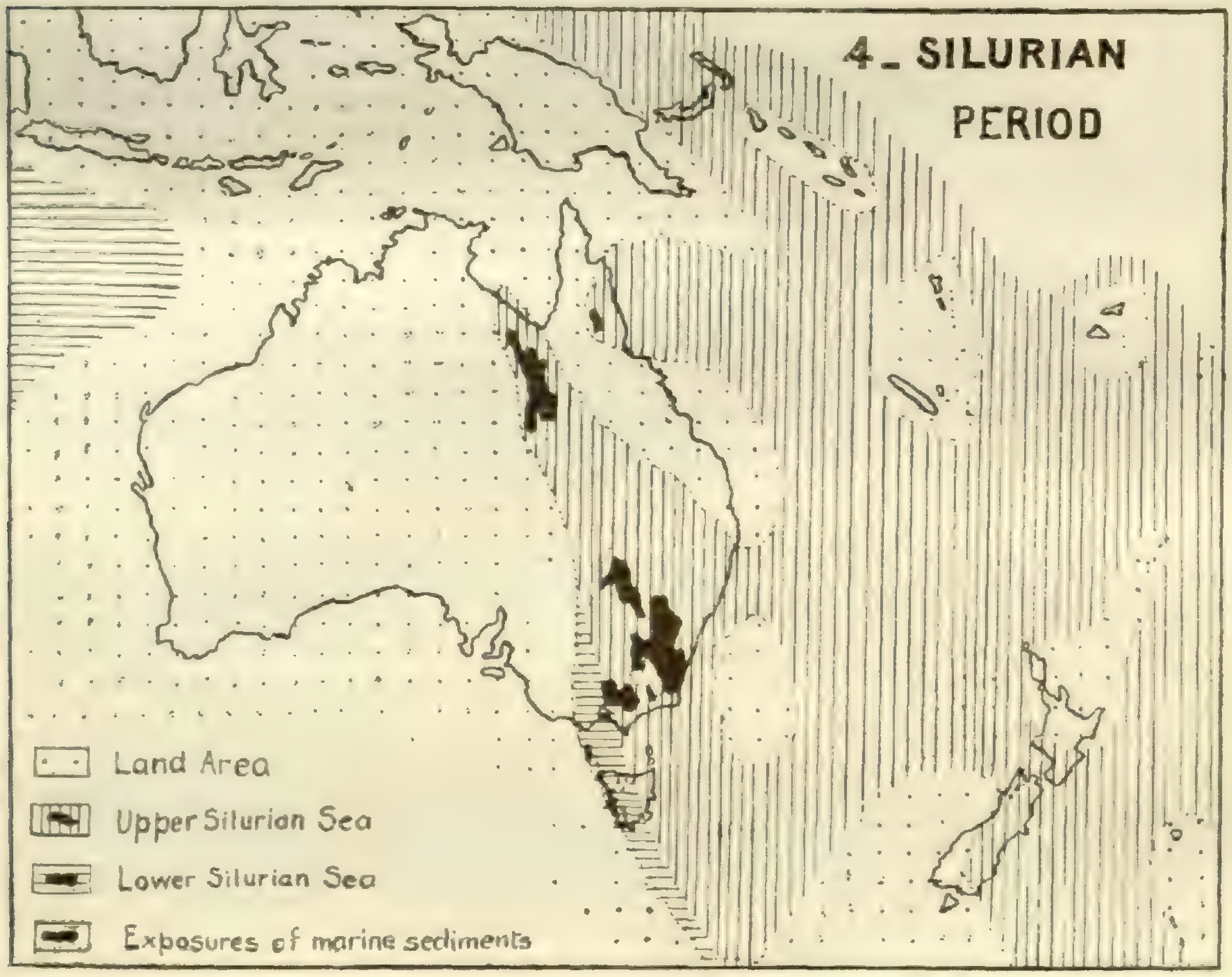
It is difficult yet to trace the sequence of events in the latter part of the Ordovician period. A strong folding doubtless occurred, and land was subjected to erosion extending throughout the present region of Australia, for where the Silurian rocks are seen in contact with the Ordovician rocks in New South Wales—*e.g.*, the Shoalhaven River as described by Woolnough (1909)—there is a marked unconformity between them. Indeed, connected with this folding there appears to have been a considerable intrusion of granites which have caused profound metamorphism, and according to Browne's observations (1914) in the south-eastern angle of that State have converted extensive masses of the Ordovician slates into mica-schists. The relationship of these to the supposed pre-Cambrian schists of eastern Victoria is not yet definite. The unconformity between the Ordovician and Silurian slates in central Victoria is not so marked. Loftus Hills (1921) has made clear their relationship in western Tasmania. The basal West Coast Range conglomerate, a

thick and continuous series, rests unconformably on the Ordovician slates and porphyroids, fragments of which it includes, and is followed by a thick annelid-bearing sandstone; above this is the fossiliferous Gordon River limestone, the fauna of which indicates an age transitional between the Ordovician and Silurian. To this we return shortly, noting, however, that its presence indicates that the orogeny occurred during Upper Ordovician time, and the subsequent transgression commenced in the concluding part of the Ordovician period. This transgression was at first very extensive; indeed, it covered at first an area perhaps as widespread as the Lower Cambrian transgression. A shallow sea extended through south-western Queensland (Jack, 1897) and the Macdonnell Ranges, where it laid down a short cycle of gently flexed sediments. The basal sandstones are followed by fossiliferous argillaceous limestones and mudstones, which are succeeded in turn by ripple-marked and current-bedded sandstones (Tate and Watt, 1896). The quartzites, &c., north of Spencer Gulf in South Australia may also be part of the same series. According to Maitland (1919), we may perhaps group as probably coeval with these the almost horizontal unfossiliferous sandstones, dolomitic limestones, &c., of the Nullagine series, which, overlying a crystalline complex, cover the greater part of the northern moiety of Western Australia, but for the present they are omitted from consideration herewith. The fossils present in the Macdonnell Ranges include the following genera: *Hyalostelia*, *Orthis*, *Isoarca*, *Palaearca*, *Pteronites*, *Eumena*, *Raphistoma*, *Ophileta*, *Orthoceras*, and *Asaphus*. Tate (*op. cit.*) thought that these indicated a "Caradocian" (uppermost Ordovician) age, and that they were approximately coeval with the Gordon River limestones, though possessing little faunal community therewith. Concerning them Reed (1910) remarks, "Though we are not able at present to judge precisely of the affinities of the Australian Ordovician neritic forms, for they are not very marked, yet the relations of the species seem to be with north European forms." It would seem, therefore, as if the late Ordovician orogeny had been accompanied by such changes in the geography of the other parts of the world as to open the Australian seas to the stream of European life-forms which dominated the fauna of the succeeding Palaeozoic periods. The marine incursion into central and western Australia was, however, but brief, and regression must have occurred by the close of the Ordovician period, but the sea continued in the eastern States, where a continuous succession of Silurian rocks was laid down.

Silurian.

The Gordon River limestone, with its transitional Ordovician-Silurian fauna, appears as the oldest of the Silurian fossiliferous formations in the eastern States. Among the forms present are *Favosites*, *Tetradium* (which was at first referred to *Archaeocyathus*), *Halysites*, *Pleurodictyum*, *Dalmanella*, *Camarotoechia*, *Pentamerus*, *Trematospira*, *Rhynchotreta*, *Trochonema*, *Raphistomina*, *Tentaculites*, *Orthoceras*, *Asaphus*, *Illaenus*, *Cromus*, and *Calymene*. These fossiliferous beds are succeeded by sandstones and slates with *Orthis*, *Spirifera*, *Pentamerus*, and *Cardiola*, which are probably equivalent to the Lower Silurian beds of Victoria (see Etheridge, 1882, 1896; Dun, 1910; Chapman, 1919). Silurian beds are represented in northern Tasmania by the Chudleigh limestone, which contains *Halysites* (Etheridge, 1898).

The extensive fauna of the Silurian rocks of Victoria has been studied in detail by Chapman (1908, 1913, 1916). The Lower Silurian (Melbournian) beds occur in the centre of Victoria, running northwards from Melbourne. They consist of mudstones and sandstones exhibiting a mixed Wenlock and Llandovery fauna. Some 135 species have been recorded. The archaic trilobite *Ampyx*, and an *Illaenus* allied to an Upper Ordovician form, are associated with *Monograptus priodon*, *Botrycrinus*, *Palaeaster*, *Palaeechinus*, *Camarotoechia*, *Lingula*, *Nucleospira*, *Rhynchotreta*, and many molluscs. The Upper Silurian (Yeringian) beds lie rather more to the east than the former, extending into Gippsland. They comprise sandstones, mudstones, and limestones, from which 200 species of fossils have been obtained with the facies of



the Wenlock limestone and Ludlow shales. *Monograptus riccartonensis* and *M. convolutus*, *Favosites*, *Heliolites*, *Clathrodictyon*, *Actinostroma*, *Atrypa*, *Chonetes*, *Orthis*, *Pentamerus*, *Platystrophia*, *Stropheodonta*, numerous molluscs. *Bronteus*, *Cheirurus*, *Encrinurus*, *Phacops*, and many ostracods occur in this rich fauna.* In the west of Gippsland there are shales containing *Panenka*, *Styolia*, *Tentaculites*, and *Kionoceras* in a small fauna of eighteen species which may represent a still higher horizon in the Silurian series; but Whitelaw (1916) has shown that these are overlain by

* An interesting feature in the Upper Silurian (Yeringian) beds is the abundance therein of corals such as *Michelinia* and *Phillipsastraea*, which are more abundant in the Devonian than in the Silurian rocks of the Northern Hemisphere, and especially of *Pleurodictyum*, which is there confined to the Devonian beds. "This constrains us to assume that certain forms of life appeared among the Gothlandian and Wenlock facies earlier in the Southern than in the Northern Hemisphere, and migrated thence during the transition period between Silurian and Devonian epochs" (Chapman, 1920).

further conglomerates, grits, sandstones, and shales with a very late Silurian fauna, if not actually transitional into the Devonian. Chapman (1913) compares the fauna of the last two formations with that of the Helderberg series in North America.

Silurian rocks form the most widespread of the Palaeozoic formations of New South Wales, and include representatives of both the lower and upper divisions, as was pointed out by De Koninck in 1877, and these correspond to Melbournian and Yeringian series respectively of Victoria. The palaeogeographic conditions, however, seem to have been somewhat complex, and we will not here attempt a detailed analysis of them. The eastern margin of the continental nucleus extended through the region of the Western Plains, and littoral conglomerates lying unconformably on the Ordovician (?) rocks are widespread near Cobar (Andrews, 1913). They also occurred farther to the south-east in the Forbes-Parkes district (Andrews, 1910A), and the Yass district (Shearsby, 1911), but are absent elsewhere, "while the general occurrence of alternating sandstones, claystones, and limestones indicates tranquil deposition in a comparatively narrow sea" (Süssmilch, 1914). The most extensive sequence of fossiliferous beds is in the Yass district. In the shales, sandstone, and limestone of the lower portion, *Tryplasma*, *Pachypora*, *Cyathophyllum*, and *Halysites* occur, with some brachiopods; while in the upper portion there is a very extensive Wenlock fauna, enumerated by Shearsby, containing many genera of corals, brachiopoda, mollusca, and trilobites, of which the following are present: *Phacops*, *Dalmanites*, *Hausmannia*, *Calymene*, *Cheirurus*, *Ceratocephalus*, *Crotocephalus*, *Sphaerexocus*, *Staurocephalus*, *Odontapleura*, *Cyphaspis*, *Harpes*, *Illaenus*, *Bronteus*, *Lichas*, *Proetus* (see De Koninck, 1877, 1898; Etheridge and Mitchell, 1891–1917; Harper, 1909; Shearsby, 1911). To the north-east of this littoral zone is one in which the dominantly phyllitic Silurian beds are intercalated with lenticular masses of limestone, notably those in the south-east of the State, and at Wombeyan, Jenolan, Bathurst, Orange-Molong, and Wellington. These are probably all to be referred to the Upper Silurian period. *Pentamerus* (*Conchidium*) *knightii* var. *stricta*, which Tschernеyschew compares to *P. vogulicus*, is characteristic of these, and with it are abundant stromatoporoids, *Favosites*, *Heliolites*, *Halysites*, *Pleurodictyum*, *Zaphrentis*, *Tryplasma*, *Cyathophyllum*, &c., sometimes with *Orthoceras* and *Astylospongia*. Some forms had a wide range, whilst others were confined to limited areas; but the meaning of this distribution has not yet been fully investigated (see Süssmilch, 1906, 1914).

In Queensland the only definite evidence of Silurian rocks has been found near Chillagoe, where the limestones contain *Favosites*, *Heliolites*, *Halysites*, *Cyathophyllum*, *Campophyllum*, and *Spongophyllum*, with *Rhynchonella* and *Pentamerus*. Ball (1918) thinks the slates and limestones of the Cloncurry district of north-western Queensland may also be of this age. They contain *Actinoceras* and *Orthoceras*, *Orthoceratites* and *Stromatopora* (Etheridge, 1911; Dunstan, 1920).

Silurian rocks are known in New Zealand also. At Reefton, in the north-west of the South Island, they are of a varied littoral character (Henderson, 1917); but at the Baton River, eighty miles to the north-east, are found the deep-water sediments, calcareous argillites. Thomson (1913) has enumerated Hector's provisional determinations of the fossils of these localities. There is naturally some difference in the faunal facies in the two regions, but so far as is indicated by the provisional (unpublished) determinations of Dun and Chapman both are comparable with the Upper

Silurian faunas of south-eastern Australia. The presence of a *Pleurodictyum* allied (*fide* Chapman) to *P. megastomum* Dun of the Australian Upper Silurian beds is an interesting connecting link. The earlier attribution of the Reefton beds to the Lower Devonian period seems to be quite unwarranted.

Summarizing the features of the Australian Silurian faunas, Reed (1910) remarks, "The mixture of Periarctic and Bohemian forms is the distinctive mark of the Silurian fauna of this region, while in New Zealand there is an intermixture of European and North American species with local elements."* As the latter statement rests only on Hector's provisional determinations made forty years ago, judgment concerning it must be suspended.

Devonian.

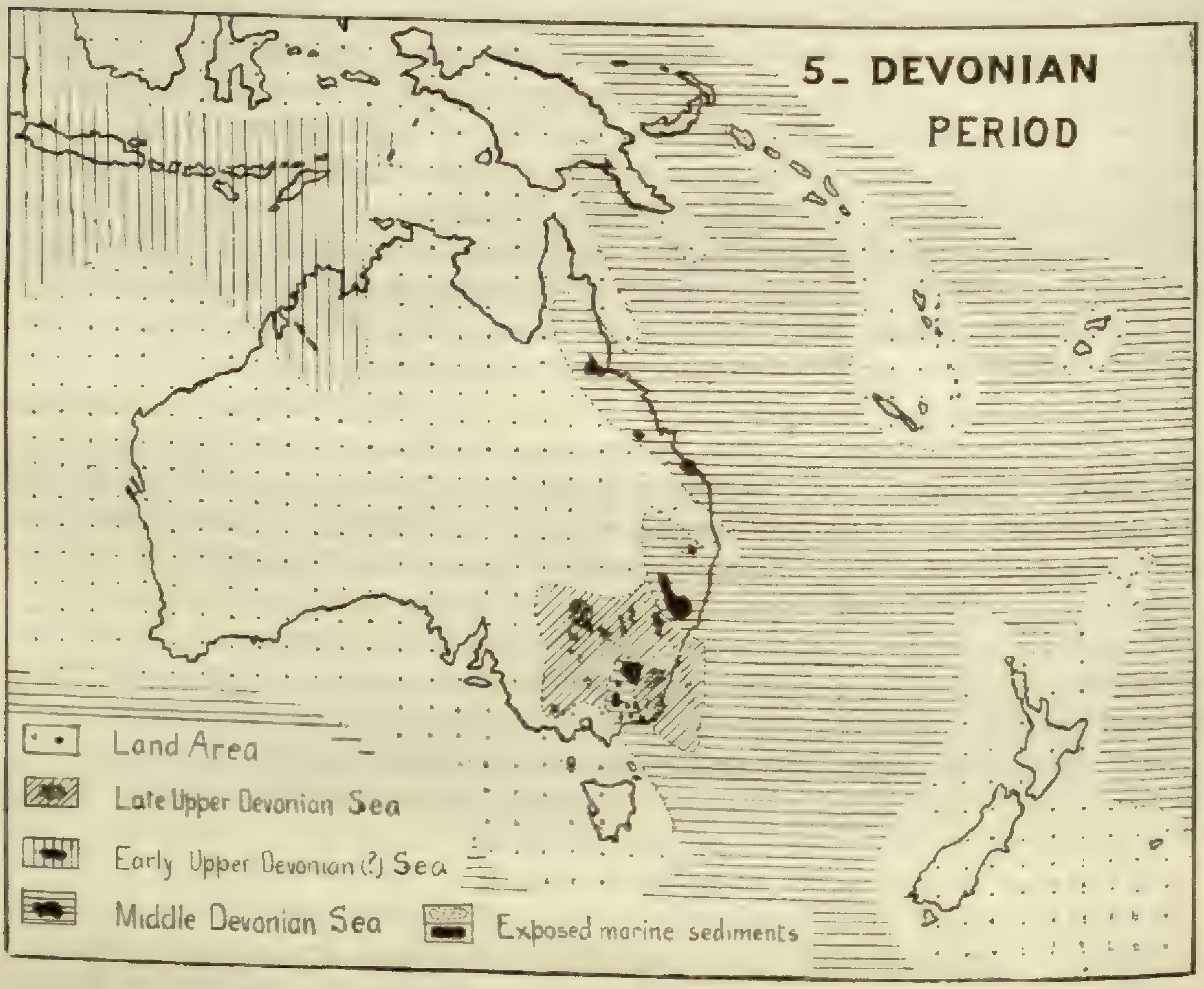
The distribution of marine Devonian formations throughout Australia has been discussed at length by the present writer (Benson, 1921), whose conclusions are here summarized. Intense folding occurred throughout the eastern States at the close of Silurian times, with intrusion of granites during the early part of Devonian times in Tasmania, Victoria, and probably south-eastern New South Wales. Land then extended to the east of the present coast. In the last two States the widespread outpouring of acid lavas which seems to have been associated with this plutonic intrusion was followed in Middle Devonian times by the formation of a long narrow trough by which the sea entered into Gippsland and southern New South Wales, where a thickness of at least 12,000 ft. of shales, limestones, and tuffs was formed. These beds contain over one hundred species of fossils, the characteristic members of the varied fauna being *Receptaculites australis* and *Spirifera yassensis*, while *Diphyphyllum gemmiformis* and various cephalopods are also important. There is not yet sufficient evidence to indicate whether this fauna should be classed with the lower or upper portion of the Middle Devonian rocks. It is not, however, followed conformably by the Upper Devonian rocks, for strong orogenic movement caused the retreat of the sea in the latter part of Middle Devonian or early Upper Devonian times, and gently inclined subaerial Upper Devonian sandstones, &c., rest with marked unconformity on strongly folded Middle Devonian rocks.

A second and larger depression occurred farther to the north, and may have been formed at an earlier date, while it certainly continued to a much later one. Andrews (1914) and David (1919) would apparently invest this trough with very considerable tectonic significance, indicating that it separated the mainland of Australia from the north-eastern land-mass, "Tasmantis," the tectonic history of which has been very different from that of the rest of Australia. How far it extended to the north-west through Queensland we cannot say, as its sediments are hidden beneath Permian and Mesozoic rocks; but there is some reason for believing that it did not continue as an open channel between New Guinea and the Northern

* An interesting instance of the wide geographic range of Australian Silurian species is afforded by Yabe's (1915) study of the genus *Halysites*. Several species originally described in Australia are found by him to be represented elsewhere: *H. süssmilchi* in Gothland, *H. australis* in Dudley, England, and *H. pycnoblastoides* in China near Yehang. (Yabe is, however, inclined to explain the similarity of the Canadian, Baltic, and Australian forms as the result of parallel evolution under analogous conditions from a common stock, rather than by a continuous intermigration of derived forms.)

Territory. To the east it may have been limited at first by the ridge now shown by the Brisbane schist, but Ball's (1921) discovery of *Heliolites* at Warwick beneath the strongly folded Permo-Carboniferous beds indicates that this barrier was flooded over at least in the latter part of Middle Devonian times, when a commingling occurred of the forms in this (the eastern) and the Queensland (or north-eastern) gulf. Richards (private communication) has found that the Devonian limestones near Warwick are associated with radiolarian claystone and tuffs like those which are so widespread in north-eastern New South Wales, as the writer's investigations have shown (*e.g.*, Benson, 1915).

The Middle Devonian beds in the eastern gulf have no visible foundation. They are an extensive series of radiolarian claystones with much tuff and three intercalated widely extending coral limestones. The lowest of these,



which may be referred to the early Middle Devonian period, contains *Favosites basaltica* var. *moonbiensis*, *F. multitabulata*, and other species, together with forms which are more characteristic of Silurian rocks, such as *Heliolites interstincta* and *Tryplasma* spp. The fauna of the next and less continuous limestone horizon is not stratigraphically distinctive. It is characterized by *Heliolites porosa*, a large *Phillipsastraea*, abundant stromatoporoids and pentamerids. The uppermost limestone may be correlated with considerable probability with the later Middle Devonian formations elsewhere. It contains a large coral fauna characterized by *Heliolites porosa*, an endemic form *Sanidophyllum*, *Spongophyllum*, *Endophyllum*, *Actinocystis*, *Microplasma*, *Litophyllum*, and the characteristic Givetian brachiopod *Stringocephalus*. In the radiolarian mudstones associated with this limestone, casts of *Lepidodendron australe* are frequently present, and continue

to abound throughout the great thickness of Upper Devonian mudstones which succeed. The sediments appear to have been formed in a widespread but comparatively shallow sea, in which explosive eruptions may have frequently built up temporary islands, especially in later Middle Devonian times.

The Devonian rocks of Queensland are less fully known, and lie for the most part in the highland regions to west of Rockhampton and Townsville. There is a very great thickness of conglomerates, sandstone, shales, and limestones, the fauna of which resembles the Upper-Middle Devonian fauna in the eastern gulf in the presence among it of *Heliolites porosa*, *Litophyllum*, and *Stringocephalus*; and, as indicated above, the two gulfs may have at one time opened into one another; nevertheless, *Lepidodendron australe* is as yet unknown in the Queensland Devonian rocks. Possibly Upper Devonian rocks succeeded these conformably, but nothing is known definitely concerning them. According to Professor David (1914), Devonian beds are represented by a grey limestone containing *Heliolites porosa* on the Tauri River in Papua (approximately 146° E., 8° S.).* Stanley (1921) states that his own observations have not confirmed this, the rocks of the region indicated being chiefly Middle Tertiary. "At the same time, there is a great chance of isolating Palaeozoic rocks in the stupendous gorges prevailing in these parts." To the north of this region is the Owen Stanley Range, in which there are phyllite sandstones and quartzites, with the blue apparently unfossiliferous limestone which, he suggests, is of Algonkian age.† Perhaps they may be the more disturbed portion of a Devonian series, and the metamorphic rocks on which they rest may be the fragment of the old "Tasmantis," but at present we can merely speculate concerning this.

Probably in the close of Middle Devonian times, or the beginning of the Upper Devonian, the sea entered the northern (Kimberley) division of Western Australia, and this movement of the strand may thus have been approximately coeval with the regression of the sea from the south-eastern trough. On a basal conglomerate was laid down a thick mass of limestone containing *Spirifera* cf. *verneuilli* (*S. disjuncta*) and *Rhynchonella* (*Hypothyris*) *cuboides*, together with stromatoporoids.

The relation of the western to the eastern Australian Middle Devonian fauna leads to interesting speculations. Reed (1910) has pointed out that among a great majority of Rhenish forms in the latter region there are a few of American affinities, and that such American influence may also be seen in the Devonian fauna of southern China, though not of Burma, nor is it present in the smaller fauna of Western Australia. This suggests that the great Tethyan migration of European forms through Asia was divided by the northern end of an ancient Cambodia-Malayan continental mass—perhaps the Aequinoctia of Abenadon (1919)—the

* See also Maitland (1905).

† In a private communication dated 24th October, 1922, Stanley says, "During my travels through the main ranges I have discovered massive crystalline limestone forming escarpments in altitude of 7,000–8,000 ft. The same features have recently been met with in the Saruvaged Mountains, Central (German) New Guinea, by Captain Retzner. These are not Tertiary, but appear to be coterminous with the Dutch occurrences (the *Alveolina* limestone of the Wilhelmina Range), and may, therefore, be Cretaceous. I have not seen any fossils in these yet." The *Alveolina* limestones, however, formerly thought to be Cretaceous, have now been placed by Rutten (1914) in the Eocene. In addition to this, we may note that Hubrecht is of the opinion that large masses of crystalline limestone in the south-west of New Guinea are really Permian (Brouwer 1919).

western division passing through Burma to Western Australia, while the other, receiving in China an influx of American forms arriving by the circumpacific channel, passed south-eastwards towards the then Tasman Sea. The complete absence of Devonian marine beds in New Zealand and New Caledonia has led the writer to suggest the land-boundaries in map 5.

Considerable changes occurred in the closing parts of Devonian time. The sea had withdrawn from Western Australia, Queensland, and the south-eastern gulf, but now emerged from the eastern gulf and transgressed widely, covering almost the whole of New South Wales, flooding over the eroded but still uneven surface of the regions which had been folded at the close of Middle Devonian times, and depositing a series of conglomerates, sandstones, and shales, which are calcareous only near the margin of the eastern gulf, where they also reach their maximum thickness of 10,000 ft. In New South Wales these beds are largely of marine origin and contain *Lingula gregaria*, *Rhynchonella pleurodon*, *R. primipilaris*, and *Spirifera disjuncta*, with many lamellibranchs. Specimens of *Lepidodendron australe* are frequent, and towards the south-east the plant-beds are more abundant and varied, and the formation passes in eastern Victoria into lithologically similar rocks containing Upper Devonian plants only, beyond which an overlapping series passes up into sandstones and shales containing a fish-fauna which Woodward (1906) declares to be of Lower Carboniferous age. Similar red sandstones and shales occurring in western Victoria, formerly thought to be Devonian, have been declared by Chapman (1917) to be of Lower Carboniferous age on account of the occurrence of *Lingula squamiformis* var. and fragments of a fish referred to the genus *Physonemus*. Since, however, *L. squamiformis* is known to occur in the Upper Devonian rocks of Wales (*cf.* Dixon, 1921, p. 50), Chapman's conclusion as to the age of these rocks may be somewhat weakened. We may, however, regard this deposit as indicating the limit of the marine transgression reached before the rapid regression which occurred in the early part of the Carboniferous period.

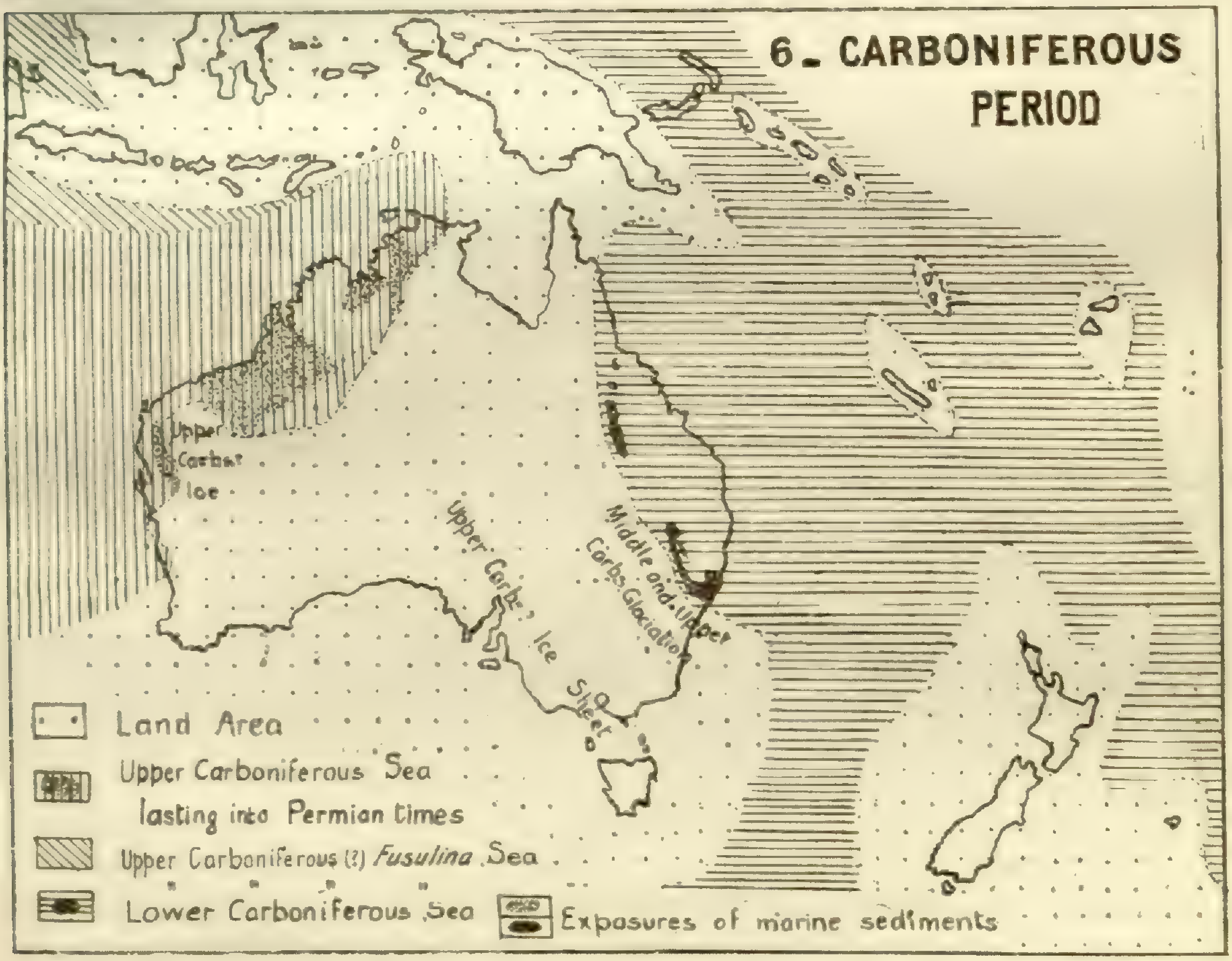
While this transgression appears to have proceeded from and receded into the eastern gulf, there is a remarkable absence of its characteristic fauna in the sediments, chiefly radiolarian mudstones, in the gulf. Only along its western margin do we find a special faunula, which is apparently a mingling of the later Middle Devonian fauna remaining in the gulf with the immigrant Upper Devonian fauna, just as there is also here a mingling of the two lithological facies.

The nature of this transgressing fauna is of interest. It has frequently been pointed out how cosmopolitan is the Upper Devonian fauna, and many of the cosmopolitan forms are present in New South Wales. Nevertheless, the work of Dun (1898) and Gürich (1901) indicates the strong affinity this fauna bears, not so much to the European developments as to the Chemung fauna of the eastern States of America; so that we may conclude that the circumpacific faunal migration became especially effective in Upper Devonian times, and in this we may perhaps see evidence that the periodicity of faunal migrations between the Asiatic and American coasts of the Pacific Ocean, which Smith (1904) declared to be a feature of Cainozoic and Mesozoic times, held good also in the Palaeozoic. If, however, in opposition to Schuchert's (1910) hypothesis that the Portage-Chemung fauna migrated directly across the Atlantic from Europe, it be supposed with Clarke (1898) that it came across the Arctic and spread south-eastwards by way of the cordilleran sea, it would follow

that the analogous eastern Asiatic and Australian Upper Devonian fauna was due mainly to an offshoot from this which passed along the western shores of the Pacific. It is worthy of note, however, that there is in the Australian Devonian faunas no community whatever with the (Lower ?) Devonian fauna of South Africa and South America, of which Clarke (1913) has given a comprehensive account. This may indicate that the Antarctic marine channel of migration, which was to become important in Upper Cretaceous times, was not yet in existence.

Carboniferous.

The characteristic Lower Carboniferous (Burindi) beds are confined to the eastern gulf in New South Wales. They follow in apparent conformity on the Upper Devonian mudstones at all points which the writer has observed along a line of contact of over one hundred miles in length (Benson, 1918),



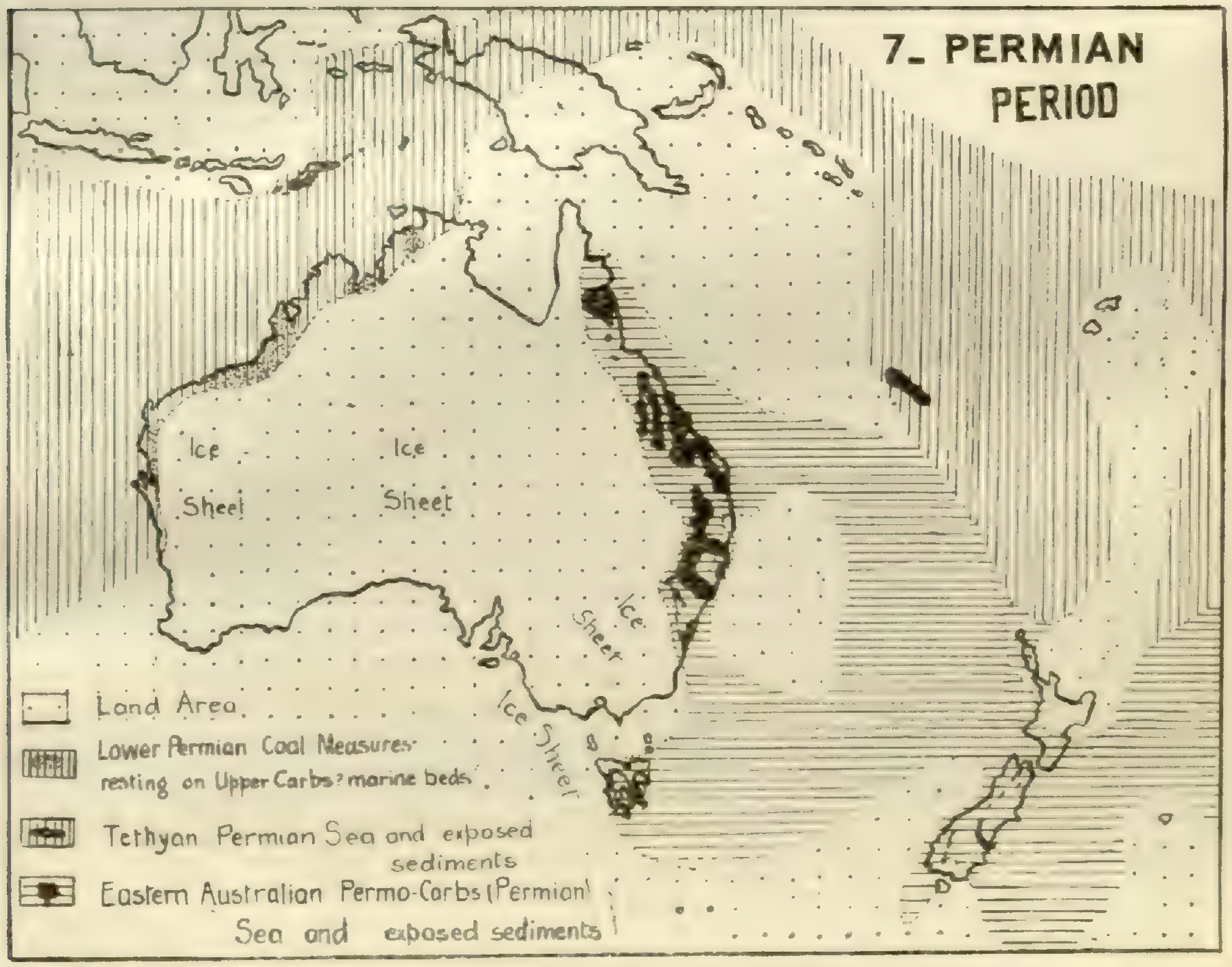
though it is possible that some disconformity may exist between them, as the faunal change is so marked; indeed, the absence of any sign of the late Upper Devonian fauna between the Middle Devonian and the Lower Carboniferous fossiliferous beds is in itself suggestive of the existence of a break in this apparently continuous series of sediments. This would accord with the view of Süssmilch (1914. 1921), though it is opposed to the writer's former belief. Süssmilch, indeed, believes that away from the region of deposition of the Lower Carboniferous marine sediments there was marked orogeny at the close of Devonian time, accounting for the intrusion of granites into the Upper Devonian quartzites west of the Blue Mountains, which granites have been since laid bare and covered by Permo-Carboniferous (Permian) sediments.

In Queensland there is no clear evidence of the existence of Upper Devonian rocks, and the widely extending Lower Carboniferous (Star) beds probably represent a transgression over a region from which the Devonian sea had regressed. There is not yet available, however, any evidence of an unconformity below them. The Lower Carboniferous fauna in Queensland is a small one, and has not yet been critically analysed; but, while it contains several forms not present in the larger fauna of New South Wales, there is no need at present to doubt the contemporaneity of the two faunas. We devote attention, therefore, to the better-known fauna of New South Wales, the information concerning which has been summarized and analysed by the writer (Benson, 1921A). It is a typical example of the cosmopolitan Culm fauna, representing the transgressive Viséan series or upper moiety of the Lower Carboniferous formation. It contains about three hundred species, of which only half a dozen are found in the Upper Devonian. Characteristic forms in it are various zaphrentids and brachiopods such as *Orthotetes crenistria*, *Chonetes laguessiana*, *Productus cora*, *P. semireticulatus*, *Leptaena analoga*, *Orthis resupinata*, *Spirifera bisulcata*, *S. striata*, *Spiriferina octoplicata*, *Reticularia lineata*, and *Actinoconchus planosulcatus*. It is perhaps remarkable for the great rarity of foraminifera, a feature which it shares with the developments of the Culm fauna in south-eastern Asia, as shown by Reed (1920) and Mansuy (1912). Though this fauna appears to have come to Australia from the Asiatic Tethys by way of the eastern Malayan route, it contains very few distinctively American elements, and thus differs markedly from the preceding fauna. That there was at this time a definite connection between the faunas of China and western North America is clear, and we shall await with interest the further light thrown on this by the investigation of the Lower Carboniferous fauna recently discovered in Japan by Yabe and Hayasaka (private communication). The relationship, however, seemed to be greater in Upper Carboniferous times. The crust-movements during the Middle Carboniferous Altaid orogeny made such geographic changes that there is a marked community between the Upper Carboniferous fauna containing *Fusulina* in western North America and eastern Asia, and perhaps to a less degree the Urals also. The American element has been clearly recognized as far to the south-east as Yun-nan (Mansuy, 1912) and Sumatra (Fliegel, 1901) mingling with Himalayan forms. The same series of crust-movements also produced most important results in Australia, which have been discussed by Professor David (1919). Briefly, these involved in the east an extensive elevation of the land, and the withdrawal of the Lower Carboniferous sea from the eastern gulf, along the margin of which a series of very active volcanoes broke out, permitting the accumulation of an immense zone of tufaceous conglomerate, lavas, and sills, extending almost meridionally throughout its whole length. Here appeared the earliest portions of the great ice-sheet that subsequently enveloped much of the whole southern part of Australia, glacial tills and seasonally banded "varve" rocks being intercalated between the tufaceous beds. There then followed the advance of the "Permo-Carboniferous" or Permian sea, which extended far beyond the limits of the Carboniferous rocks in New South Wales and submerged almost the whole of Tasmania, though Victoria remained emergent. Though this appears clear in the two States mentioned, the relationship of the Lower Carboniferous to the "Permo-Carboniferous" (or, as we shall subsequently term it, the Permian) system in Queensland is still incompletely understood, though the

misconceptions involved in the institution of the Gympie series (Jack, 1892) are now fairly clear. To this region we return, but digress here to consider events in the west.

"Permo-Carboniferous" or Permian.

Towards the close of Carboniferous times the sea entered the north-western region of Australia, in which were laid down tillites, shales, gypsiferous claystones, mudstones, and limestone, followed by *Glossopteris*-bearing coal-measures. Etheridge's (1914) investigations of the fauna of these mudstones and limestones has been recently analysed by Professor David (1919) with interesting results. There appear in it typical members of the Lower Carboniferous fauna mingled with members of the Himalayan or Salt Range fauna, such as *Hexagonella crucialis*,



Derbya senilis, *Orthotetes crenistria*, *Productus subquadratus*, *Spirifera musakheylensis*, and *Sp. marcoui*. Professor David concludes that it represents the fauna of a gulf extending from the main Tethyan channel in late Carboniferous times, in which survived a large group of Culm forms. As we shall see, the eastern Australian Permian fauna was also derived from the Tethyan channel, but it is, nevertheless, markedly different from that just noted. "One must emphasize the extraordinary effectiveness of the Darwin-to-Adelaide mountainous land-barrier which in 'Permo-Carboniferous' or Upper Carboniferous times so completely isolated the Western Australian and Northern Territory seas on the one hand from those of eastern Australia on the other. Out of about two hundred species recorded in the Permo-Carboniferous marine fauna of eastern Australia and Tasmania, only about nine are at present known to be common to the two" (David, 1919).

No less marked is the want of community between the Permian marine fauna of eastern Australia and the preceding Lower Carboniferous fauna. There are only twelve (or possibly nineteen) species common to the two series, and we have, therefore, to discover a different source for the two faunas. While the eastern Australian Permian fauna has not very much in common with the *Fusulina* Upper Carboniferous fauna of eastern Asia, it has a marked affinity with the Salt Range fauna, an affinity which does not, however, amount to identity of species (*fide* Dun), and there are several endemic genera. Among the brachiopods *Martiniopsis* is very abundant; also alate Spiriferidae, *Productus* and *Strophalosia*. The mollusca include *Agathiceras* and the typical Salt Range genus *Eurydesma*, which is absent from Western Australia; *Choenomya*, which is very characteristic of the Permian of Nebraska; and endemic genera such as *Cleobis*, *Moeonia*, *Notomya*, *Deltopecten*, and *Aphanaia*, with some cosmopolitan genera. There is little, however, distinctive among the gasteropoda (Dana, 1849; De Koninck, 1877; Johnston, 1888; Etheridge, 1891, 1892; Etheridge and Dun, 1906, 1910; Dun, 1914) nor among the foraminifera (Chapman and Howchin, 1905).

Piroutet (1917) has found the Australian species of *Aphanaia gigantea* in the argillites of the eastern portion of New Caledonia, while farther west, in the gritty littoral beds of the same formation, there are the typically Tethyan cephalopods *Waagenoceras*, *Stacheoceras*, and *Popanoceras*, which occur at intervals between this region and Sicily.

In New Zealand also is a faunula showing Australian affinities, though containing nothing typically Tethyan. Trechmann (1917) described from the Wairoa Gorge, near Nelson—the fossiliferous locality found by McKay (1878) and taken by Hector as proving the Carboniferous age of his Maitai series—the following group of forms: *Rhynchonella* cf. *pleurodon*, *Martiniopsis subradiata*, *Spirifera* cf. *bisulcata*, *Strophalosia* (? cf. *gerardi*), *Platyschisma* sp., *Pleurotomaria* sp., and an obscure form (previously termed the "Dun Mountain *Inoceramus*") which he refers to *Aphanaia*, though according to Mr. Dun (verbal communication) this is not a member of that genus, but differs widely from it, and is apparently without parallel among the described Australian species. Attention may, however, be directed to the form occurring in the Permian ("Carboniferous") rocks of Hobart, which R. M. Johnston termed *Inoceramus elegantula*, though his illustration of it (*Geol. of Tasmania*, pl. xv, fig. 13) does not suggest affinity with either the "Dun Mountain *Inoceramus*" or *Aphanaia*.

Omitting at the moment further discussion of eastern Australasian palaeogeography, we turn to consider the source of this fauna. Along the Tethyan route, Timor would seem to have been in the stream of migration. The Permian fossils found in this island by Rothpletz (1892) and Boehm (1907) contain several forms, notably *Streptorhynchus* cf. *crenistria*, *Reticularia lineata*, *Cleiothyris roysii*, *Productus semireticulatus*, *P. abichi*, *Spirifera musakheylensis*, and *Lyttonia* sp., which are present in the Upper Carboniferous rocks of Western Australia and the *Productus* limestones of India.* The first four of these are represented by closely allied forms in the Lower Carboniferous but not in the Permian of eastern Australia, the latter having no direct representatives in the Timor Permian

* If it should be that the attribution of *Rhynchonella timorensis* to the Devonian rather than to the Upper Carboniferous of Western Australia is mistaken (Foord, 1890), we should have yet another link between the Western Australian and Timor fauna.

fauna. The Himalayan affinities of the latter are emphasized by the presence of *Chonetellus nasuta*, *Productus asperulus*, *P. gratiosus*, *Stacheoceras* sp., and indicate close relationship with the fauna of Chitichun, on the Thibetan frontier, which is the open-sea equivalent of the littoral fauna of the Middle *Productus* limestone (Haug, 1911, p. 805-8; Schuchert, 1906). We may thus recognize a stream of Tethyan forms undergoing considerable evolution as they migrated south-eastwards. The development in Timor indicates the region from which an epicontinental extension of the fauna branched out to north-western Australia; while the main stream, perhaps passing between the shattered residual portions of an ancient continental mass stretching to the north-westwards from Australia—the Aequinoctia, which Abenadon (1919) believes broke up at this time—spread into the seas on the eastern margin of Australia, and there evolved during the closing part of the Carboniferous period into the provincial fauna which characterizes the region (compare Dun, 1914; David, 1919).

Since the above was written access has been obtained to the summaries of the geology of the eastern and western portions of the Malay Archipelago by Brouwer (1919) and Van Es (1919) respectively. These are of such importance for Australasian geology that the following abstract of the portion dealing with the Permian rocks has been incorporated here. Permian rocks are represented in south-western New Guinea by littoral sandstones containing fragments of crinoids, *Spiriferina?*, *Orthis?*, a rhynchonellid, and *Proetus*, originally described by Martin (1911), and a large thickness of shales and limestones in the Snow and Hellwig Mountains, farther north. Crinoidal remains are found in Luang and Babar, and also in Letti, where Molengraaff (1915) found that the series of fossiliferous littoral sediments in the south of the island pass northwards into schists. The fossils consist chiefly of brachiopods and crinoids, with Fusulinidae and ammonites such as *Agathiceras* (a genus represented by *A. micromphalum* in both Western Australia and New South Wales). Broili's (1915) account of the brachiopods indicates the presence of the following Himalayan forms: *Productus cora*, *P. spiralis*, *Spirifera fasciger* (= *S. musakheylensis*), *Reticularia lineata*, *Martinia nucula*, and *Chonetes strophomenoides* (all but the last two being also present in Western Australia), and *Spirifera rajah*, which is closely allied to the characteristic eastern Australian form *S. tasmaniensis*.

In Timor itself the littoral deposits are more richly fossiliferous, but detailed accounts of the fauna are not here available. There is a great wealth of mostly endemic echinoderms described by Wanner (1916), and of cephalopods (Haniel, 1915); the latter include, besides those mentioned above, *Gastrioceras* (which, with *A. micromphalum*, marks a definite zone in Western Australia), *Waagenoceras*, *Popanoceras*, *Cyclolobus*, *Medlicottia*, and other Himalayan genera, together with a large series of brachiopods described by Broili (1916), "which give less definite evidence of age" (*cf.* Schuchert, 1906). Haniel (1915), on the basis of the ammonite fauna, has recognized four stages in these rocks. The lowest is coeval with the lower part of the Artinsk beds (Lower Permian), but contains some Carboniferous elements; the second is Upper Artinsk-Sosio; no analogy is suggested for the third, which is placed in the lower part of the Upper Permian series: the fourth is compared with the Middle and Upper *Productus* limestone of Upper Permian age. Schubert (1915) considers the Fusulinidae indicative of an Upper Carboniferous age, but Van Es (1919) believes them to be Permian, to which period also Brouwer (1919)

refers the whole series. "The nearest relatives of all the Permian faunas investigated up to the present are to be found in the Permian of the Alps, of Sicily, of the Urals, of the Salt Range, and in the Himalayas, while the Permian sediments of Timor also correspond in a great degree with the Wichita formation in North America. We thus see that the Tethys geosyncline, of the duration of which in Mesozoic times we usually think, was marked in the Permian and extended from the Mediterranean area to the East Indian Archipelago. But a certain independence appears in the development of the faunas, so that the connection between them was not completely open . . . and it is not remarkable that littoral sediments should have been formed [here] in this geosyncline" (Brouwer, 1919).

The presence of fossiliferous Permian beds in Rotti and Savu has also been noted, but in Java the oldest exposed formations are Cretaceous. An important Permian series is developed in western Sumatra, of which Van Es's (1919) discussion is very illuminating. The lowest exposed members of the series are cherty limestones containing foraminifera, notably *Sumatrina annae*, *Schwagerina verbeeki*, and *Doliolina lepida*. These three forms Deprat (1912) found to abound in the upper term of a threefold series in Yun-nan, of which the middle and lower terms contain Lower Permian and Upper Carboniferous brachiopods, &c., and rest unconformably on Middle and Lower Carboniferous strata. Above the foraminiferal beds in Sumatra lie further limestones with a diversified fauna in which Fliegel (1901), who thought them to be Upper Carboniferous, described a number of new species which have since been found in the Permian of Timor. Locally coal-measures occur interbedded with these, and contain *Pecopteris*. Rather noteworthy, according to Fliegel, is the absence of such Himalayan genera as *Lyttonia*, *Richthofenia*, *Oldhamia*, *Aulosteges*, and *Strophalosia*, most of which occur in Timor.

Exactly where the line should be drawn between the Carboniferous and Permian rocks is a problem of long standing. The diversity of views thereon, as expressed in the "Report on Nomenclature of the Carboniferous, Permo-Carboniferous, and Permian Rocks of the Southern Hemisphere," presented to the British Association in 1915 and 1917, and in Professor David's (1919) last discussion of the question, is indicated in the following diagram:—

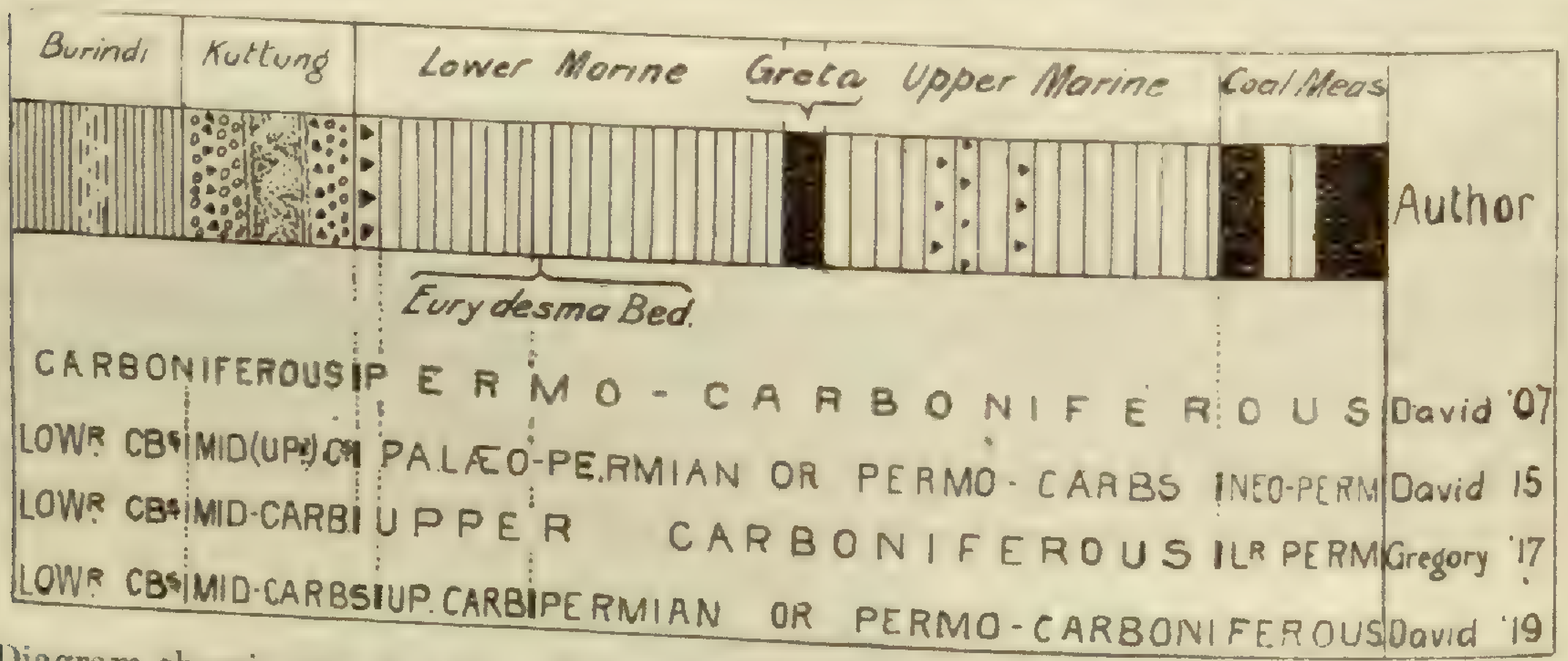


Diagram showing various classifications of the Carboniferous and Permo-Carboniferous beds of New South Wales. (Relative thicknesses not to scale.)

The palaeogeographic features of eastern Australia during the period have long been studied by Professor David (*e.g.*, 1907), and are also being

studied by Dr. Walkom, whose preliminary conclusions concerning north-eastern New South Wales have already been stated (1913). We shall not, therefore, anticipate further work, but shall briefly summarize our present knowledge of the region.

The marine beds are grouped into a lower and an upper series, deposition having been interrupted by a regression, when lagoons or "inland seas" existed, in which the Greta coal-measures, or their equivalents, were deposited in New South Wales, Queensland, and Tasmania. In each of these States also a second series of coal-measures was formed during the final regression of the Palaeozoic seas from eastern Australia. The marine deposits throughout give evidence of their formation in comparatively shallow seas, and there are many indications that they were laid down between the Australian mainland and an eastern land-mass that is now submerged.

The ice-sheet which had first gathered on the mainland in Middle Carboniferous times probably reached its maximum at the close of that period, and fluctuations of the ice-front during early Permian times seem to be indicated by the presence of unusually abundant erratics dropped from floating bergs, at several horizons in the marine rocks (see, *e.g.*, David, 1907A).

Crust-movement occurred during Permian times in north-eastern New South Wales and southern Queensland. Dr. Walkom's (1913) palaeogeographic maps indicate that this region, though an area of deposition during the Lower Marine period, became a promontory against which the second marine invasion was divided, and the westerly portion of it transgressed considerably farther on to the continent than did the first marine transgression. This crust-movement was apparently a prelude to the intrusion of the extensive series of granites in north-eastern Australia. The details of the distribution of the "Upper and Lower Marine" (Permian) series in Queensland form a very difficult study, concerning which comparatively little is yet clear, though much useful work has been done (see, *e.g.*, Dunstan's tabulation, 1916); and the discussion of the palaeogeographic significance of this, and also of the occurrences in Tasmania, must await fuller treatment by other writers. We must note merely that at the close of this period the sea withdrew completely from Australia, and we find that the land-masses of "Tasmantis" had become united to the Australian continent by the commencement of Triassic times.

As noted above, the discovery of *Glossopteris indica* near the South Pole permits us to infer that a part at least of Antarctica formed one of the groups of closely connected continental masses which made up the Permian or Permo-Carboniferous Gondwanaland, and affords us the first intimation, since Lower Cambrian times, of communication between Australia and Antarctica and the inception of that with South America. It is therefore of interest to inquire the extent to which the varied Indo-Australian fauna on the littoral of Gondwanaland is represented on either side of the South Atlantic, the Devonian fauna of which is so strikingly different from the Australian. Though Haug (1911, p. 817) indicates that Upper Carboniferous marine rocks form a rather widespread sheet transgressing from the Andean geosyncline on to the continental massif to the east, the only account of these rocks accessible to the writer is that of Douglas (1914), who determined fourteen species from South Peru and Bolivia, most of which "appear to belong to an Upper Carboniferous or Permo-Carboniferous fauna showing affinities with types . . . from the Urals, while a few seem more nearly

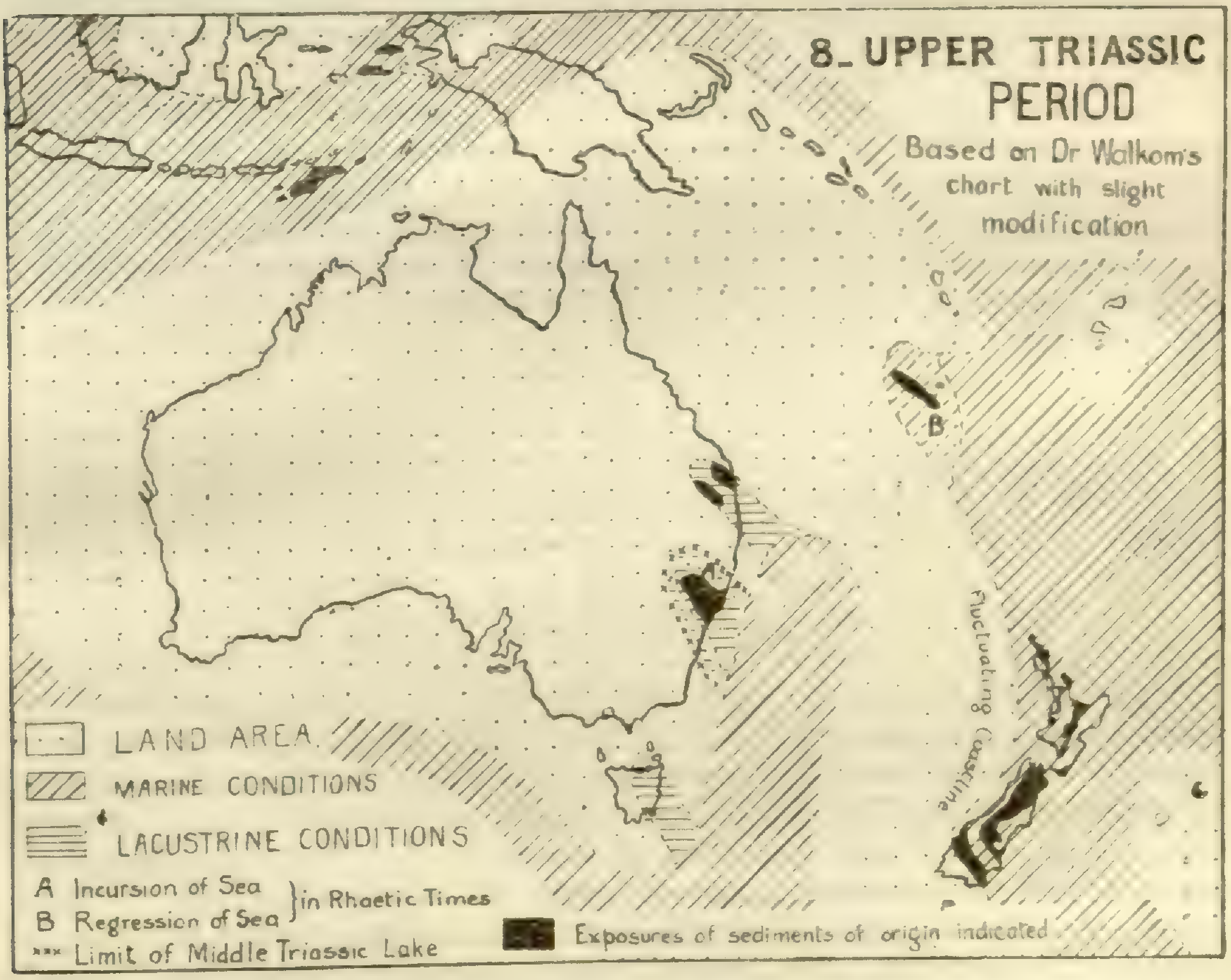
related to Permian forms from the Salt Range of India, and from the Guadalupian fauna of New Mexico." No eastern Australian forms are present. In Keidel's (1922) recent work (for the translation of which the writer is indebted to Professor Elder) the marine beds in the Pre-Cordillera of the western Argentine, supposed by Stappenbeck (1910) to be of Upper Carboniferous or later age on account of the presence of a form resembling *Spirifera supramosquensis*, are shown to be interstratified with tillite, and to contain a number of other species of *Spirifera*, *Dielasma*, and other brachiopods, *Pleurotomaria*, and several other gasteropods, all rather imperfectly preserved and not yet specifically determined. This group of glacial and marine beds has been traced for about a hundred kilometres north and south, and throughout has been thrust to the east on to the Gondwanan continental massif. It appears, however, to have been deposited unconformably on the Lower Carboniferous and earlier Palaeozoic beds that form the western margin of that massif. Keidel terms these glacial and marine beds the Tontal series, and correlates them with the Permian beds of Australia. Some unnamed marine fossils of this age have been found by Oliveira and recorded by Woodworth (1912) from Rio Negro in south-eastern Brazil, and in south-western Africa *Conularia* and the Indian form *Eurydesma globosum* have been found by Schroeder (1909) associated with the Dwyka tillite. There is thus no clear evidence of the migration of marine forms during the Permo-Carboniferous period along a hypothetical Southern Pacific Gondwanaland coast between Australasia and South America.

We return to consider the Permo-Carboniferous or Permian record in New Zealand. It may be remarked parenthetically that the author's substitution of the term "Permian" for "Permo-Carboniferous" as the age of the Maitai series was at first influenced by the supposed presence of *Aphanaia* therein, a form belonging to the "Upper Marine" series of New South Wales, in which also the other New Zealand forms are represented, excepting *Spirifera* cf. *bisulcata*, which occurs in the Lower Marine beds but more usually in the Lower Carboniferous, and *Rhynchonella* cf. *pleurodon*, which occurs in the Upper Devonian and but rarely in the Lower Carboniferous. It may perhaps be doubted whether these determinations are quite correct, as the best specimens available were not good; but, such as they are, they seem to suggest that it would be preferable still to employ the term "Permo-Carboniferous," as Trechmann proposed, to indicate the age of the Maitai series, rather than "Permian" merely, as the writer has done. Little can be stated definitely in regard to the distribution of this series in New Zealand. Fragments of a thin prismatic shell presumed to be the Dun Mountain "*Inoceramus*" of McKay, or the "*Aphanaia*" of Trechmann, are widespread in the greywackes throughout the South Island, and in default of better evidence may be taken as characterizing "Maitai" rocks in several regions in South Canterbury and North Otago, and in the western parts of Southland. Professor Park (1921) has recently recorded some limestones, probably belonging to the same series, at the northern end of the Livingstone Range, west of Lake Wakatipu. In these he noticed the presence of *Productus*, *Spirifera*, and obscure corals and gasteropods. The suggestion that eastern Southland made a resistant crust-block at this period (Benson, 1921) has been considered in preparing the map herewith. It may, however, also have been submerged. Distinct though the affinity is between the faunas of eastern Australia and New Zealand, there is also evidence of a considerable independence, and perhaps the New Zealand

area may have been littoral to a Southland-Chatham Island continent, not glaciated, nor supporting *Glossopteris*, rather than to the Australian mainland. Neither drifted erratics* nor *Glossopteris* have been proved to occur in the Maitai series; but, as no fresh-water beds are known in the Maitai series (in its restricted sense), this last point may not be very significant, and does not appear to vitiate the suggestions in the map.

Triassic.

Directly following on the "Permian" Maitai beds, and generally referred to the upper portion of that series, is a thick group of often more siliceous shales and greywackes, extending into the North Island near Wellington, and containing an annelid referred to *Torlessia mackayi* (Bather, 1905–6). Jaworski (1915), however, refers it to *Terebellina* sp., and considers it to be Triassic. We may, perhaps, tentatively accept this view



as to age, and class it with the Lower Triassic beds of New Caledonia, which also follow conformably on the Permian rocks. What followed the deposition of these is not clear. Various writers have claimed a perfect conformity; a disconformity, or an extensive folding with plutonic intrusions, is indicated between the Lower and Upper Triassic beds (see discussion, Benson, 1921). Marshall, however, who in 1912 strongly upheld the first view, has concluded (1917A), since Trechmann's description of the Maitai fossils, that a break of some kind must occur between these

* Professor Park (1920) has discovered striated boulders in a breccia in eastern Otago which may be either of dynamical or glacial origin. He inclines to the latter explanation. They appear to be in "Maitai" rocks.

and the Triassic fossils; and Park (1921) has revived Hutton's view that this was a period of great orogeny and intrusion of plutonic rocks, including among them the diorite-gneisses and associated plutonic rocks of south-western New Zealand and the peridotites, &c., of Nelson. In New Caledonia a regression of the sea in Middle Triassic times is indicated (Piroutet, 1917).

The relationships of New Zealand and New Caledonia during the Triassic period are of great interest. While *Terebellina* (?) *mackayi*, with *Dentalium huttoni*, and possibly other forms, seem the only representatives yet known of the life in New Zealand during Lower Triassic times, in New Caledonia there were present characteristically Tethyan (mostly Himalayan) Lower Triassic forms such as *Pseudomonotis* aff. *painkhandana*, *Ophiceras*, *Flemingites*, *Meekoceras*, *Aspidites*, *Koninckites*, *Danubites*, and *Dorycranites*. An analogous series of forms occur in Timor in beds following conformably on the Permian sediments (Brouwer, 1919). These are also represented to some extent in eastern Asia, whence they apparently migrated into California, since the community of character of the forms on either side of the Pacific was very marked in Lower Triassic times, indicating an intimate connection of the two regions, which became interrupted during the crust-movements of Middle Triassic times (Smith, 1904). We see, therefore, that the extension of the Tethyan coast to New Caledonia, but not to New Zealand, was a feature of Lower Triassic as well as of Permian times. Regression occurred during Middle Triassic times. Beds of this age are absent from Sumatra (Volz, 1899) and Rotti, but are present in Timor containing a neritic cephalopod fauna more like that of the Alpine than the Asiatic Tethys (Brouwer, 1919), and in New Caledonia are represented by an incomplete series on the western slopes containing *Daonella arctica* (a Siberian form); but on the east Upper Triassic rests directly on Lower Triassic (Piroutet, 1917). The crust-movements which occurred at this time in New Caledonia, and probably in New Zealand, joined the two lands so intimately that in Upper Triassic times they formed a well-marked province in the south-eastern extremity of the Tethys. This, Wilckens (1920) suggests, may be termed the Maorian province. It possesses features distinguishing it from the Himalayan and Malayan fauna (with which, nevertheless, it has much in common); and, moreover, the fauna is not yet known in New Guinea, so that Walkom's suggestion (1918) that a northward extension of Australia projected into Malaysia—which would prevent the free south-eastward migration of the Tethyan fauna—accords well with the conclusions we have formed concerning earlier epochs. Nevertheless, the Upper Triassic transgression was felt throughout the whole region considered. Volz (1899) found Upper Triassic forms resting directly on the Permian sediments in Sumatra. In Timor and Rotti, Carnic forms (*Daonella* and *Halobia*) and Noric (*Pseudomonotis ochotica*) are present (Wanner, 1907); and other islands of the archipelago—Misol, Ceram, &c.—show also a development of Upper Triassic marine beds, though as a result of a general regression at the close of Triassic times no Rhaetic sediments appear to be developed throughout the whole archipelago (Brouwer, 1919). The close affinity between the records of Upper Triassic times in New Caledonia and New Zealand has been indicated (Benson, 1921) by a tabular comparison of the recent work of Piroutet (1917) and Trechmann (1917B), modified by Wilckens (in MS.), who, concurring with Trechmann in most points, suggests there is not any good evidence for the Ladinian age of the lowest portion of the mostly

Upper Triassic series in New Zealand. The following table summarizes the facts known :—

COMPARISON OF UPPER TRIASSIC PALAEONTOLOGICAL ZONES IN NEW ZEALAND AND NEW CALEDONIA.

New Zealand.	New Caledonia.
RHAETIC.	
Arcestes cf. *rheticus* ; *Mentzelia* ; *Clavigera*	Marine regression preliminary to orogenic movement.
NORIC.	
Pseudomonotis ochotica (zone locally missing)	*Pseudomonotis* sp. ; cephalopods ; *Rhynchonella* spp., &c.
Pseudomonotis richmondiana (abundant, but zone locally missing)	*Pseudomonotis richmondiana* (abundant).
Spiriferina spp.	*Spirigera*, *Spiriferina*, &c. ; *Pseudomonotis* sp. ; *Halobia* cf. *rarestriata* (zone locally missing).
CARNIC.	
Halobia zitteli var. *zealandica*, *H. hochstetteri*, *H.* cf. *austriaca* ; *Myophoria* and gasteropods ; *Spiriferina* sp. ; *Spirigera wreyi* ; *Halorella* sp. ; *Retzia* sp. ; *Discophyllites* sp. ; *Arcestes*	*Halobia hochstetteri*, *H. austriaca* ; *Spirigera wreyi* ; *Discophyllites* ; *Arcestes* spp. *Myophoria* and gasteropods ; *H. hochstetteri*, *H. austriaca* ; *Retzia* ; *Halorella* ; *Spiriferina*.
"*Mytilus*" *problematicus**	"*Mytilus*" *problematicus*.
Halobia spp.	*Halobia zitteli*, *H.* spp.
Myophoria nuggetensis ; *Halorella* sp. ; *Spiriferina* sp.	*Myophoria* sp. ; *Halobia* sp.
Spiriferina cf. *fragilis* ; *Daonella indica* ..	*Spiriferina* cf. *fragilis* ; *Rhynchonella* sp. ; *Terebratula* sp.

* *Myalina ? (Maoria ?) problematica* Wilckens (in MS.).

It will appear from the above that crust-movement, commencing in Rhaetic times, greatly displaced the coast-line in New Caledonia, which remained raised above the sea-level until near the close of Jurassic times ; while in New Zealand the Triassic conditions were continued into the Jurassic without much permanent geographic change. Near and probably west of both these areas of marine deposition there was a land-mass, and in the minor fluctuations of the strand-line across the coastal shelf there were formed intercalations of fresh-water plant-bearing beds in the predominantly marine strata.

Concerning the palaeogeographic significance of the Upper Triassic fauna, Dr. Trechmann's analysis of that of New Zealand shows that all the forms other than indigenous are represented in the Malay Archipelago, Himalayas, or Alps, except *Pseudomonotis ochotica*, which extends from Timor to Japan and eastern Siberia, and under the name of *P. subcircularis* is found at intervals down the Pacific Coast as far south as the Republic of Colombia. The northern circumpacific channel of migration was, therefore, effective during Upper Triassic times.

Leaving the coastal regions, we turn to consider the conditions of the Australasian continental surface during the Mesozoic times, basing our discussion on Dr. Walkom's (1918, &c.) notable work, supplemented by

that of Dr. Arber (1917) for New Zealand. To the former is due the Triassic and Jurassic maps here given (with minor modifications). Extensive fresh-water deposits formed in the neighbourhood of Sydney, comprising the extensive conglomerates, shales, and sandstones of the Narrabeen and Hawkesbury series, of probably early and middle Triassic age. The basin of deposition probably discharged into a northward-extending gulf ancestral to the Tasman Sea. In Rhaetic times the area of sedimentation increased. A second basin formed in south-eastern Queensland (the Ipswich series), and another, probably in Tasmania, discharging into the same gulf, which seemed to have reached a maximum extension at this time, for the deposition of the Rhaetic lacustrine Wianamatta shales above the Hawkesbury sandstone was interrupted near its close by a brief incursion of the sea passing from this gulf as far westwards as the Blue Mountains. Here it deposited an argillaceous limestone containing a small group of ostracods and foraminifera, "a brackish or estuarine fauna having a curious intermingling of Rhaetic and Lower Jurassic types with others more properly referable to the Upper Palaeozoic of Europe" (Chapman, 1909).* It is interesting to note the close approximation in time between this temporary ingression of the sea into eastern Australia and its regression from New Caledonia.

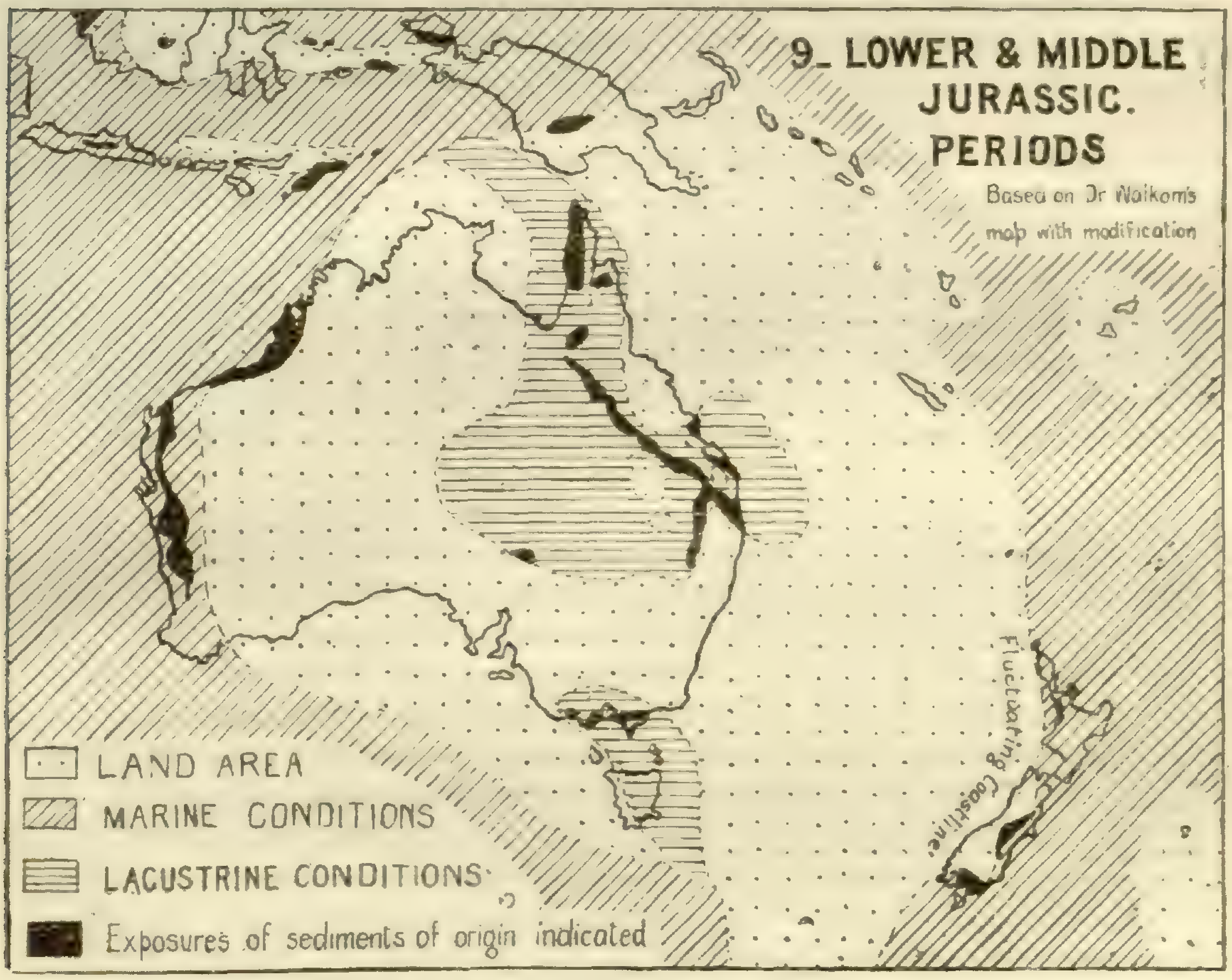
Jurassic.

The Jurassic period witnessed a wider extension of these lacustrine deposits. Walkom (1918) shows them as stretching from the Cape York Peninsula southwards and to the northern parts of South Australia and of New South Wales. He is of the opinion that this basin discharged into the sea by some outlet to the north, and was not connected with a south-eastern sea by a Queensland Gulf such as Neumayr had supposed. A second basin is that comprising the Jurassic coalfields of Victoria and eastern Tasmania, which Walkom thinks may have drained into the Southern Ocean. The intervening region of the present Tasman Sea, he considers, was probably for the most part a land area, the coast of which lay east of New Caledonia (which was land till near the close of Jurassic times), but west of New Zealand, which formed the littoral zone across which the strand fluctuated (until the early part of Cretaceous time), producing intercalated marine and fresh-water deposits, the latter predominating in the latter part of the period. The comparison of the work of Walkom on the Australian flora, and of Arber on that of New Zealand, briefly summarized by the writer (Benson, 1919), indicates a very general similarity, though with comparatively few forms common to the two regions. In general, also, the Australian Mesozoic flora contains four times as many species as that of New Zealand, perhaps due to the unfavourable littoral habitat of the latter, and the modifications which have ensued during their migration back and forth with the fluctuation of the coast-line. The general conditions indicated continued until the commencement of the Cretaceous period, the highest plant-beds in this series in New Zealand being those of Waikato Heads, which Arber considers of Neocomian age: in these, associated with *Cladophlebis* and *Taeniopteris*, appear angiospermous leaves (*Artocarpidium*), which seem to be more related to the figs than to any other modern plants. Of about the same age as these are the much larger floras described by Walkom (1919) from the Burrum and

* It is perhaps more than a coincidence that the time-range of the foraminifera should thus be analogous with that suggested by the fish-fossils in the Wainamatta series (Woodward, 1908).

Styx River beds in Queensland. The former contains thirty-six species, a typical Wealden association, free from angiosperms; the latter, which probably belongs to a slightly higher horizon, contains three angiosperms out of fourteen forms. Both these Queensland floras contain *Microphyllopteris*, a genus instituted by Arber (1917) to receive one of the forms present at the Waikato Heads. Walkom (1919), indeed, remarks on the resemblance of the Styx River flora to that of Waikato Heads.

We thus see the grounds for Arber's conclusion that "in Rhaetic and probably also Jurassic times New Zealand and Tasmania were united with Australia as one large connected land area. The flora of these now separated regions are nearly allied but not identical, but the similarity between them is probably sufficient to allow of this hypothesis." Further,



we must note his remark that "as regards Antarctica, we have no evidence as yet of any Rhaetic land there, but in Jurassic times Graham's Land may have been connected with New Zealand and also with Australia." Nevertheless, we must recall that the Mesozoic flora was a remarkably cosmopolitan one, and accordingly the provincial affinities must be unusually clear to give much support to palaeogeographic hypothesis. Special interest attaches, therefore, to the form *Linguifolium*, which was supposed to belong to *Glossopteris* prior to Arber's investigations.* It occurs in the

* The late Dr. Arber concluded that "there is no evidence that New Zealand formed part of Gondwanaland"; but this, in Seward's opinion, is open to question. "The leaves on which the genus *Linguifolium* is founded are, I believe, generically identical with, or at least closely related to, *Glossopteris*. There is, moreover, a close resemblance shown by several New Zealand species of plants with those of the Rhaetic floras of Tonkin, South Africa, and elsewhere, which contain representatives of *Glossopteris* or other members of the later flora of the Gondwana continent" (Seward, 1914, p. 39). Arber's (1917) reply to this criticism should also be noted.

Rhaetic and Lower Jurassic beds in New Zealand, and Arber believes the genus is represented in the Rhaetic beds of South America and the Jurassic of Australia, though Walkom does not concur in regard to the last. It is perhaps also represented in the Noric beds of New Caledonia by leaves stated by Piroutet (1917) to be "like *Glossopteris*."

Leaving the land area, we return to trace the Australasian coast-line north-westwards from New Zealand. The most extensive development of strata of this age is that of marine and fresh-water beds which cover the south-eastern portion of the Dominion, and in their gently undulating character are so different from the adjacent steeply folded strata of the Hokonui Hills and the Alps farther to the north as to suggest that they represent a transgression of the Jurassic sea over a resistant mass—either a promontory of the ancient continental platform or a foreign block in the broad geosynclinal region splitting apart the Takitimu and Hokonui Ranges. The affinities of this fauna have recently been made more clear by Trechmann and Spath (1921), but an abstract only of their work is as yet available.* The series, which is probably about 10,000 ft. in thickness, ranges from Lower Liassic to Upper Jurassic. The affinities exhibited by the fauna are with forms occurring in the Argentine, Andes, Western Australia, Sula Islands, Spiti Shales, and Kutch, while the ammonites which are referable to the Middle Lias have a typically Mediterranean aspect. The highest portion of the series occurs at Kawhia, and fossils from here have been studied also by Boehm (1911), who recognized, besides the circumpacific types of *Aucella*, *Lima*, *Inoceramus*, and *Phylloceras*, previously noted by Zittel and Hector, additional forms—a *Streblites* and *Perisphinctes*—and stated that the well-known *Ammonites novozealandicus* (Hauer) was a species of *Hoplites* (*Berriasella*). Upper Jurassic marine beds underlie the Neocomian plant-beds of the Waikato Heads, and this association, noted by Hochstetter and Cox, has been redescribed by Gilbert (1921).

On the eastern flanks of the main ranges of the North Island, however, the upper portion of the older Mesozoic series is a considerable thickness of sparsely fossiliferous greywacke containing *Inoceramus*. In the Gisborne district these beds have also yielded an obscure species of *Turritella* which appears to resemble (*fide* Marwick) some forms recently described by

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* Since writing the above the author has been permitted by Dr. Trechmann to see and cite from portion of the manuscript of his unpublished paper, from which the following facts are culled. The oldest of the Jurassic fossils in New Zealand were obtained from beds in the Hokonui Hills, in the South Island, apparently transitional between the Otapiri and Bastion series of Hector (see table, Benson, 1921, p. 59). They contained, with *Pecten*, *Astarte*, *Tancredia* (?), and *Oxytoma*, some species of the Hettangian (basal Lias) ammonite *Wachneroceras*. At a higher horizon in the Bastion beds of the same region, the "*Plagiostoma*" (*Pseudomonotis ?*) beds contained some rather obscure lammellibranchs and Rhynchonellidae with a "Callovian" (Middle Jurassic) aspect. These are followed by beds with a fauna analogous to that of Kawhia Harbour, in the North Island, where are developed *Aucella spitiensis*, *Arca* (*Parallelodon*) *egertonensis*. *A. blanfordiana*, *Inoceramus haastii* (allied to *I. galoi*), *Terebratula octoplicata*, and *Rhynchonella pulcherrima*, a group of Bathonian (Lower-Middle Jurassic) forms, together with forms of *Phylloceras* like *P. passati* and *P. malayanum*, described by Boehm from the Oxfordian (Upper-Middle Jurassic) of the Sula Islands. Trechmann's provisional determination, cited by Gilbert (1921), of the fossils in the beds immediately underlying the "Neocomian" flora of Waikato Heads, a short distance to the north, shows the presence of the lamellibranchs of this group. A higher series of beds in the Kawhia Harbour, of Kimmeridgian-Tithonian (Upper Jurassic) age, is characterized by *Streblites* cf. *motutaranus*, *Perisphinctes* spp., and *Belemnites* spp., which are also represented in the Sula Islands. The absence of this fauna from beneath the Neocomian beds of Waikato Heads suggests the existence of a hiatus in the Jurassic series there.

Etheridge (1920) from the Rolling Downs beds of Queensland. These rocks are termed the Awanui or East Coast series, and with them we may perhaps group the Manaia series of greywackes and conglomerates in the Coromandel Peninsula. The East Coast series are believed by Mr. Morgan to have been formed during late Jurassic and early Cretaceous times, immediately preceding the retreat of the sea prior to the intense orogeny which occurred in Lower Cretaceous times.

In New Caledonia the land exposed by the retreat of the sea in Rhaetic times endured until near the close of the Jurassic period, when a transgression occurred, the strand-line moving from west to east. The incoming marine fauna contained a *Berriasella* closely allied to *B. novozealandicus* (Piroutet, 1917). Thus regression in New Zealand, with the formations of the plant-beds of Waikato Heads (the prelude to the early Cretaceous orogeny), followed hard on the transgression of the strand in New Caledonia, but the trangression was of short duration. In eastern New Guinea (Papua) a marine trangression occurred in Middle (?) and later Jurassic times. Etheridge (1889) described some poorly preserved forms from the Fly River which he referred to *Stephanoceras* cf. *calloviensis*,* *S.* aff. *lamellosum*, *S.* cf. *blagdeni* (or *S.* cf. *coronatus*), *Macrocephalites* sp., and *Belemnopsis* sp. Haug (1911) reports the occurrence of these forms also, but appears here, as in other cases, to have assigned what seemed to be the most probable names to figured and provisionally determined fossils. In northern and south-western New Guinea the same series appears to extend. Boehm (1906) places the formations as ranging from Callovian to Lower Cretaceous, and has determined a number of better-preserved fossils. Of these, *Macrocephalites keeuwensis* α and *M. keeuwensis* β-γ are believed to be the equivalents respectively of the first two of the above list of forms determined by Etheridge (Boehm, 1913). *Phylloceras*, *Stephanoceras*, *Sphaeroceras*, *Perisphinctes*, *Hoplites*, *Oppelia*, *Hamites* (?), *Belemnites Posidonomya* (?), *Inoceramus*, and *Rhynchonella* aff. *moluccana* are also recognized by him. The same geologist has traced this fauna westwards into the Sula Islands, Buru, Babar, Timor, and Rotti, thus surrounding the Banda Sea. In these there is an indication of a distinctively equatorial sea of about Callovian age, an extension of the Tethyan syncline marginal to the Australasian massif (Boehm, 1907). There is, however, an important southern epicontinental extension of the sea which flooded over the western parts of the Australian continent (which must then have extended farther to the west), producing a thickness of about 2,000 ft. of shallow-water deposits, yellow, brownish, or reddish calcareous sandstone, occasionally plant-bearing (Arber, 1910; Walkom, 1921), passing locally into yellow limestone. Moore (1870) recognized twenty European species with nine new forms, and considered the beds to be of Oolitic age. Crick (1894), as a result of his examination of the cephalopods, considered the beds as belonging to the Lower Oolitic period. He recognized species of *Stephanoceras*, *Dorsetensia*, *Perisphinctes*, and also *Belemnites canaliculatus*. Chapman (1904) supported this. Boehm (1907) remarked that the fauna was mid-European in its facies, and considered it to have been deposited in the Callovian extension of the equatorial Tethys. Haug (1911, p. 1045) believed the Bajocian and Callovian strata were represented here. Etheridge (1910) added a few more European forms to the list of Western Australian forms, which was completely tabulated by Glauert in the same year. Trechmann and Spath have noted

* *Kepplerites calloviensis*, according to Haug (1911).

several features of community between the Western Australian fauna and that of New Zealand.

It is interesting to note that Neumayr (1883) was of the opinion that Australasia and China were connected during Jurassic times into a single continental mass; but the discovery of the Malayan developments of the marine fauna has caused certain authors—*e.g.*, Lemoine (1906) and Haug (1911)—to substitute the conception of an Australo-Indo-Madagascan continent, over which there transgressed epicontinental seas into Western Australia and the Runn of Kutch during the Bajocian - Callovian epoch. Uhlig (1911) recognized in this a western development of the Mediterranean-Caucasian faunal province which merged into the Himalayan, of which he regarded as extensions the West African, West Australian, and New Zealand developments. These exhibit marked affinity with the faunas of the Japanese and South Andean provinces, though the contrast they show with the boreal and North Andean province prevents us recognizing a circumpacific geosyncline. The conclusions of Trechmann and Spath (1921) accord with this, and thus are not opposed to the hypothesis of a Jurassic land connection between South America and Australasia suggested by palaeobotanical evidence, and, according to Hedley (1911), by modern biogeography.

A further conception of Neumayr's must also be considered. Hedley (1909) has restated it from a biogeographic standpoint as follows: "A meridional crease in the earth's crust produced in Jurassic times a gulf, which he called the Gulf of Queensland, whose western shore transgressed the present east Australian coast. Enlarging through geological cycles, this gulf grew into what we know now as the Tasman and Coral Seas. . . . As the Mesozoic sink enlarged its periphery it became a dominant factor in land-configuration. First it broke through an inner earth-fold of which New Caledonia and the Louisades are relics. Then, continuing its work to the eastwards, it submerged a younger outer continental ridge on which the Solomons stand. Westerly it crumpled up the former coast of north Queensland, and by a further western effort broke open Torres Straits. While the Coral Sea was yet a prolongation of the old gulf, it offered a refuge to old forms of life. The low latitude afforded a warm unchangeable climate, and the surrounding continental extension (New Guinea – New Zealand) secluded its inhabitants from the incursion and competition of other tropical fauna. When, however, continued subsidence to the east at last burst through the Melanesian plateau, a flood of active competitors must have swept in from the open Pacific. . . . With the opening of Torres Straits, and the consequent outgoing current, the Queensland fauna was spread along north Australia to the Moluccas."

Walkom (1918), in discussing the above, points out that the late Triassic foraminiferal beds near Sydney form the most important piece of evidence of the existence of this gulf, and "there is no evidence at all to show that this gulf transgressed the present east coast of Australia during Jurassic time. . . . The gulf was probably more or less coincident with the present position of the Thomson Trough, but whether this trough is as old as Lower Mesozoic is difficult to determine." His palaeogeographic map (1918, fig. 5) illustrated his conclusion that during Jurassic times the eastern coast of Australasia remained in much the same position as it was in during the Triassic period,* and to the south the Gulf of Queensland disappeared, or was very much reduced.

* Piroutet's conclusion concerning the Jurassic emergence of New Caledonia was not available at the time Dr. Walkom wrote.

Lyman Clarke's (1921) study of the modern echinoderms of Torres Straits has led to the following conclusions:* "Hedley's hypothesis of a Queensland Gulf in Mesozoic time receives no support from the echinoderms. What may be called the original echinoderm fauna was on the north-west side of the present continent, and was of East Indian origin and Indo-Pacific composition. On the other hand, confirmation is afforded for Hedley's view that, as land areas east of New Guinea subsided, the Coral Sea became connected with the Pacific; its western shores also receded until the Great Barrier Reef was formed. This sea was invaded by echinoderms from the Pacific. . . . Continued subsidence on both sides led at last to the formation of Torres Strait, and the East Indian echinoderms then migrated eastward and southward to the Queensland coast, where they mingled with Pacific immigrants. The latter, however, had not passed westward through the straits." (Parenthetically, we may here recall the strong physiographic evidence of the westward retreat of the Queensland coast to its present position in comparatively recent times: *cf.* David, 1911.)

Late Jurassic, Lower and Middle Cretaceous.

We have already seen that the marine sequence of earlier Mesozoic beds in New Zealand was concluded by the Tithonian or uppermost Jurassic beds at Kawhia, and the possibly early Cretaceous *Inoceramus*-bearing greywackes of the east coast, and, further, that the commencement of the retreat of the sea in New Zealand was approximately coeval with its entry into New Caledonia, which has been emergent throughout the earlier part of the Jurassic period. This sea, which passed from west to east across the island, brought in at first *Berriasella* (*Hoplites* cf. *novozealandica*), together with several species of *Trigonia*, *Alaria*, and undetermined gasteropods. Piroutet has not yet discussed the affinities of these, but apparently European, Indian, and western American forms are represented. A more extensive though still restricted series of three stages follows these Tithonian beds, the uppermost of which is the chief repository for coal in the island. It contains a further species of *Trigonia*, which is compared with a form† in the Maryborough beds of Queensland which Piroutet (1917) thought belonged "d'un niveau très elévé des Rolling Downs beds," but which, as we shall see, are of lowest Cretaceous age or even Upper Jurassic. With this form there occur in New Caledonia shells allied to *Pholadomya elongata* and *Exogyra couloni*, which occur in the lowest Cretaceous beds of southern Europe. This coal-bearing series is followed with but slight unconformity by the Senonian St. Vincent beds, so that here the Mid-Cretaceous emergence was not associated with any orogenic movement.

Jurassic-Cretaceous passage-beds are known also in several localities along the north coast of Dutch New Guinea, and closely resembling these are coeval beds in the Sula Islands characterized by *Phylloceras strigile*, *Lytoceras*, *Bochianites*, *Streblites*, *Hoplites*, *Himalayites*, *Nucula*, *Mytilus*, and *Anopaea*, a facies recalling that of the Spiti shales. Besides these are rather widespread foraminiferal limestones passing into *Globigerina* marl with belemnites, and known as the Buru limestone. It occurs in Buru, Ceram, Misol, Eastern Celebes, and Timor.

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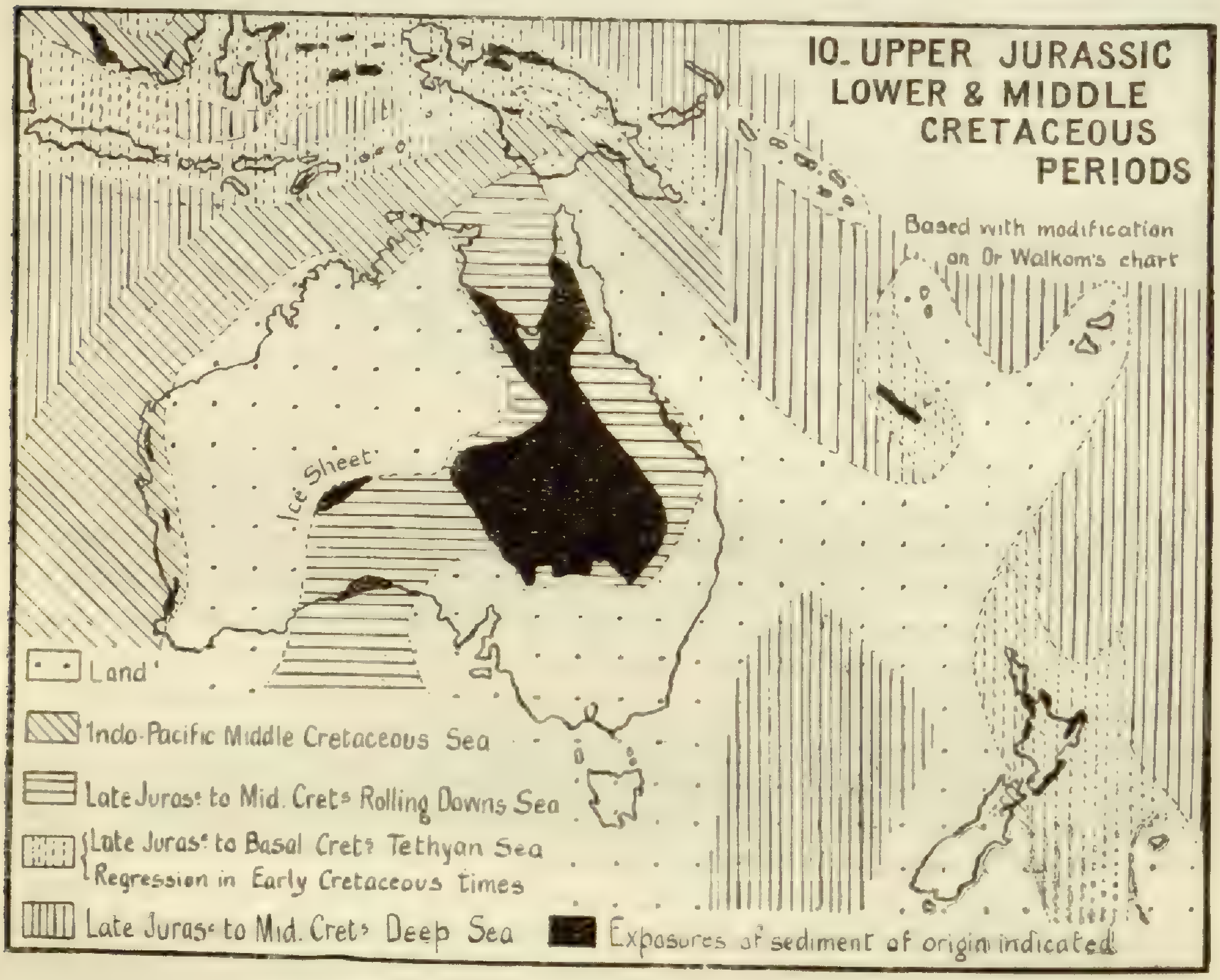
* Review by F. A. B. in *Nature*, 4th August, 1921.

† Concerning this species Etheridge (1892, p. 471) remarked that it "has a strong resemblance to a small and peculiar species, *T. semiornata*, figured by A. d'Orbigny from the Cretaceous rocks of South America."

Far more extensive than the above are the marine sediments of the Rolling Downs formation in Australia, concerning which ideas at present are somewhat uncertain. As recently as in 1914 Professor David, in summarizing their occurrence, declared them to be a Lower Cretaceous series of glauconitic sands and clays, almost wholly of marine origin, passing conformably downwards into fresh-water Jurassic rocks, and followed unconformably by the Desert Sandstone, largely of fresh-water origin, though containing marine fossils at Croydon in Queensland, and at Port Darwin. Since then Dunstan (1916, 1920) has shown that the term "Desert Sandstone" has been applied to lithologically similar rocks of various ages, including parts of the Rolling Downs formation itself, such as the Croydon beds mentioned above, and he has therefore abandoned the term altogether, proposing the name "Winton series" for the Upper



Cretaceous and early Tertiary fresh-water beds, which lie conformably on the lower series in Queensland, though with slight unconformity in other regions. Though Jack (1892) at first despaired of reducing to a definite sequence the apparent mixture of Jurassic and Cretaceous forms in the "Rolling Downs" formation, terming the whole Lower Cretaceous, Etheridge (1902), after the examination of many cores obtained from artesian wells, felt that "the time is not far distant when we shall be in a position to break up our continental Cretaceous system into a number of well-defined life-zones." Gürich (1901) had previously discussed the age of a collection from these beds near Wilcannia, and had referred them to the Jurassic on apparently inadequate evidence. Particular interest attaches, however, to the age of the Maryborough plant-bearing marine bed, which at first was classed with the "Desert Sandstones" as Upper

Cretaceous. Out of a described fauna of thirty-two species, eighteen occur in the Rolling Downs beds (Etheridge 1892A, 1901; Chapman, 1913). with which the Maryborough bed has since been correlated. Walkom (1919) has shown that the flora of the Maryborough bed appears to be an Upper Jurassic one, being free from angiosperms, while that of the immediately overlying Burrum beds is of the Neocomian type. He therefore concludes that the Maryborough marine fauna will probably have to be considered as Upper Jurassic, and to this period we may thus tentatively refer the lower portions of the Rolling Downs series.

In north-western Queensland there are widespread water-bearing limestones which Dunstan (1920) considers to be of fresh-water origin and Jurassic age, and to lie conformably beneath the Rolling Downs series. On account of the lithological character of these rocks, Woolnough (1912) has compared them with the adjacent partly silicified Lower Cambrian limestones. Danes (1916), however, states that he has found foraminifera in them, the specimens being referred to *Operculina*, *Globigerina*. *Nodosaria*, *Haplophragmium*, *Cristellaria*, and *Textularia*, a group of genera which give little indication of the age of the formation. Dunstan (1916) is disposed to agree with Jensen (1914), who suggests that these are merely Tertiary fossils occurring just like the adjacent but rare accumulations of Tertiary mollusca—namely, in small "pockets" in the surface of the Cambrian (?) limestone.

Referring to the fauna of the Rolling Downs beds, among the most distinctive fossils are certain foraminifera, chiefly Lituolidae, and the endemic lamellibranchs *Maccoyella*, *Pseudoavicula*. and *Fissiluna*, and the large cephalopods *Crioceras* and *Ancyloceras*. According to Etheridge and Dun's (1902) enumeration, the fauna contains 234 species, of which 100 are lamellibranchs, and nearly all are endemic, though out of a score of forms mentioned as having close allies outside of Australia sixteen are represented in India or Europe,* and two recently-described gasteropods resemble Californian forms (Etheridge, 1920).

Among the forms reported with representatives in extra-Australian areas are *Crioceras australe* in the Aptian beds of India, and *Inoceramus crispi*, a world-wide Cenomanian form, with species related to other types in the Cenomanian series with which both Haug (1911) and Woods (1917) correlate the upper part of the Rolling Downs beds. The report (Hector. 1886) that *Belemnites australis*, a Rolling Downs form, occurs also in the Jurassic beds of the Kawhia and Waikato Heads is the result of a mistaken identification, but *B. aucklandicus* in the same series is very like *B. liversidgei* in the Rolling Downs beds (Etheridge, 1892A, p. 491).

In regard to the origin of this fauna, Professor David (1914) and Mr. Dun (1914, 1919) believe that it was developed in an extensive but shallow epicontinental sea, which, extending out from the region of the present Gulf of Carpentaria, covered nearly a third of the continent. It is possible, as Haug suggests, that the transgression may have been more extensive in Middle Cretaceous times than in those immediately prior thereto, but of this there is not yet sufficient proof. The Maryborough

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* Haug (1911) remarks, "All these forms have been described as new species with scarcely any identification with European species. It is probable, however, that the differences are more apparent than real." In explanation of this it should be noted that Mr. Etheridge frequently stated his method of nomenclature, which accords with Uhlig's (1911) principle: "I do not consider it wise to identify a form with a species described from a region thousands of miles distant unless the agreement is so close as to leave no room for doubt as to their identity."

fauna is so like that elsewhere in the Rolling Downs series that it appears preferable to consider the former as deposited not in a separate gulf, as Walkom indicates (1918), but as the extension of the sea into and beyond the northern depressed area wherein Jurassic sedimentation had taken place. There is also some doubt (expressed notably by Ward—private communication) as to whether this Cretaceous sea reached as far south as the bight where Cretaceous fossils have been found in strata concealed by overlying Lower Tertiary beds. Ward draws attention to the present absence of any connecting strata crossing the broad area of ancient gneisses and other crystalline rocks between these and the main mid-continental development. That such a connecting zone may have been present, and has now been very largely stripped off, laying bare its foundation, is suggested by the occurrence at Eucla, in beds beneath the Tertiary cover, of typically Rolling Downs genera such as *Maccoyella corbiensis*, *Aucella hughendenensis*, and *Fissiluna*, reported by Maitland (1919). This is indicated on the chart, which is a modification of that suggested by Walkom (1918). In this great mediterranean the fauna developed many endemic forms sharply distinct from those on the north-west coast of the continent, as will be shown. We may here record parenthetically the recent discovery by Talbot and Clarke (1918) of glaciated boulders in these rocks in the south-east of Western Australia, thus confirming an earlier report of a similar discovery by H. Y. L. Brown (1905) in the northern parts of South Australia. Each of the authors considers the glaciation to be of late Cretaceous age, or possibly early Tertiary (see also David, 1907).

Following the Cenomanian period of greatest flooding, there seems to have been an almost complete withdrawal of the sea from central Australia, and a slight crust-flexing and erosion took place before the formation of the Upper Cretaceous or Tertiary flood-plain deposits, so that in Upper Cretaceous times central Australia was mostly emergent, while the sea was transgressing on to the marginal regions of New Caledonia and New Zealand.

The occurrence of Cretaceous rocks in Western Australia is quite different from the above. At Gingin is a small area of chalky limestone, the most richly fossiliferous development of a series of Cretaceous rocks which underlie the coastal lowland near Perth. It contains the sponge *Peronella*, the coral *Coelosmilia*, and the brachiopods *Trigonesmus*, *Magas*, and *Magasella*, forms foreign to the rest of Australia, and allied to those in the Upper Cretaceous beds of India and South Africa. With these are also species of *Inoceramus* and ammonites, which are related to forms in the Rolling Downs beds (Etheridge, 1913). Chapman (1917A) has recognized 134 species of foraminifera in this rock, fifty-nine of which are restricted to the Cretaceous in other parts, chiefly Europe, and of these a fairly large number have hitherto been known only in the Gault (Albian) formations. He therefore concludes that the fauna is, on the whole, not Lower Cretaceous, but Albian-Cenomanian. It thus probably represents a middle Cretaceous expansion of the enlarging Indian Ocean which occurred about the time of the first transgressions of the Indo-Pacific fauna on to the eastern margin of Australasia, and that of the retreat of the sea from its central region. Twenty of the species recognized have also been recorded by Howchin (1893) from central Australia.

Near Port Darwin *Belemnites* beds stated to be of "Upper Cretaceous" age occur in "numerous pockets and patches mostly of slight area along

the coastal fringe" (Jensen, 1914). They are composed of cherty sandstones, and contain numerous radiolaria (Hinde, 1893). They appear to overlie a Rolling Downs series, of which, however, no examples can be seen, unless they are exposed on the south of Melville Island, though wave-torn fragments of *Scaphites* and *Rhynchonella* derived therefrom are thrown up on to the beach (Woolnough, 1912). Little has been published concerning the detailed features of this district. It would seem, as pointed out by Dun (1914, 1919), that the Northern Territory in Cretaceous times played a rôle somewhat as in preceding epochs, separating an eastern mediterranean, where local forms developed, from a western region in which there is a more obvious relationship to the Indian faunal facies.

In western Borneo sandstone, claystone, and marl occur, characterized by the Cenomanian ammonite *Cnemoceras*, and adjacent to these are coeval plant-bearing sandstones and limestones with *Orbitolina concava*. Similar limestones appear in the Meratus Range, in the south-east of the island. These seem to indicate a small marine transgression in Middle Cretaceous times.

In New Guinea there are rather indefinite evidences of a Middle Cretaceous transgression. In the south, on the Strickland, a tributary of the Fly River, *Inoceramus concentricus* has been obtained (Etheridge, 1889). More recently a considerable extent of these rocks has been found (by the Lorenz, 1907, expedition ?). Professor David (1914) concludes that the Cretaceous transgression probably covered the whole island. The sediments are steeply dipping, and mostly dark-green calcareous and glauconitic (?) sandstones and limestones containing *Inoceramus*, *Gryphaea*, *Modiola*, *Aviculopecten*, *Protocardium*, *Cidaris*, *Belemnites* with *Alveolina* and *Orbitolites*. According to Rutten (1914), however, the two genera of foraminifera are in the Lower Tertiary rather than in the Cretaceous beds. It is the limestone containing these that is so widely distributed throughout the mountain-chain of western New Guinea, and possibly extends into the eastern half of the island. (See second footnote, p. 27.)

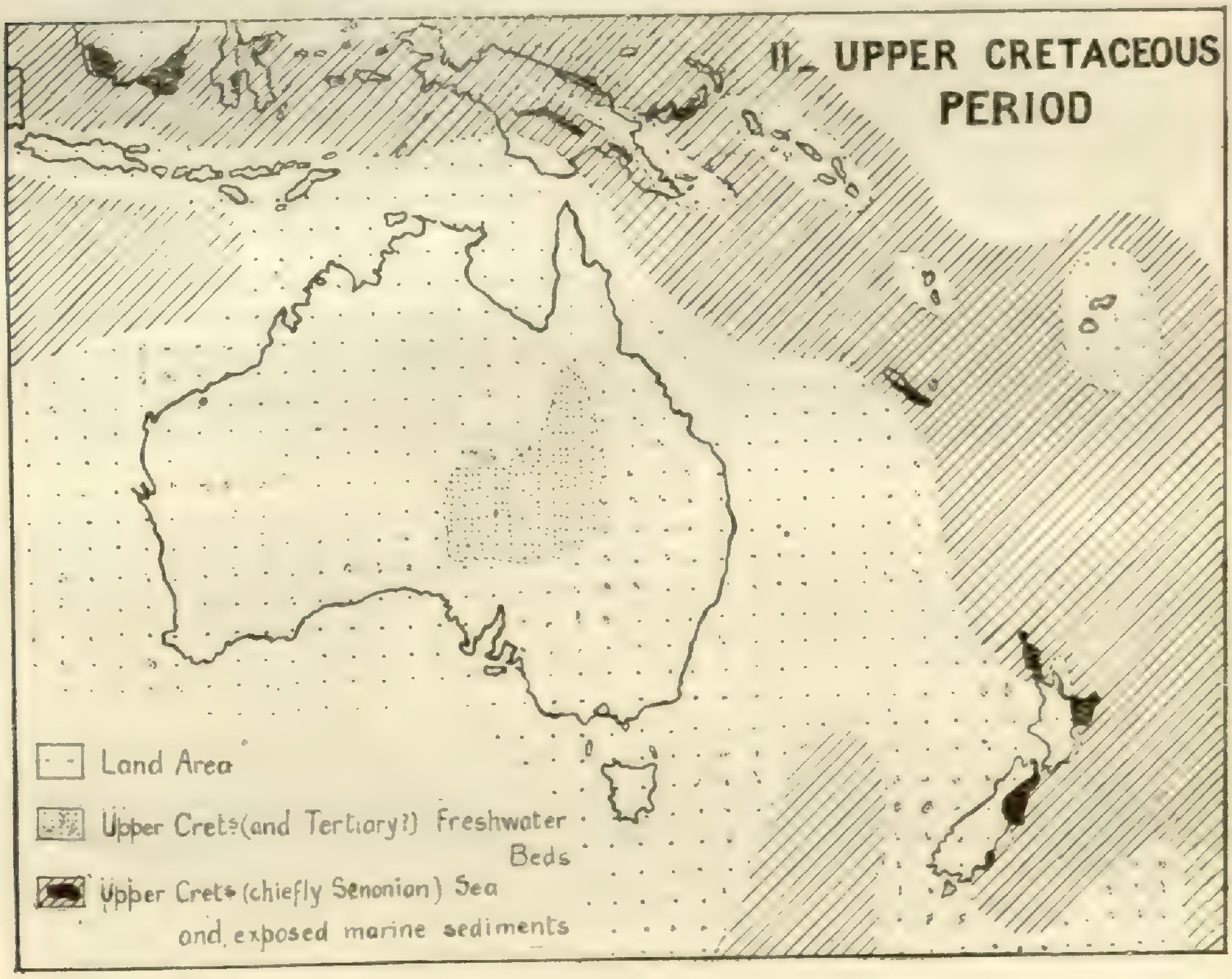
No Middle Cretaceous rocks are known in New Caledonia, where Upper Cretaceous beds rest directly upon Lower Cretaceous, so that a long emergence must have been here the feature of Middle Cretaceous time. The same is true in regard to the North Island of New Zealand; but that some depression of the New Zealand area occurred at this time is shown by the entry of Middle Cretaceous sea into the north-eastern corner of the South Island. Here the basement beds rest on an unevenly eroded surface of intensely folded (probably) Lower Mesozoic rocks; and, as there is no evidence of folding during the Mesozoic times prior to the commencement of the Cretceous period, this very intense orogeny must have occurred during Lower Cretaceous times. The Middle Cretaceous sands and clays have a maximum thickness of 8,000 ft., and contain sixteen described species of fossils, mostly lamellibranchs, including *Inoceramus concentricus*, with the cephalopods *Gaudryceras sacya* and *Turrilites circumtaeniatus*, forms widely distributed in the Indo-Pacific Lower Utatúr beds, and probably contemporaneous with the Albian beds and the upper part of the Rolling Downs formation (Woods, 1917). Unless Marshall's (1917) suggestion is correct—viz., that these beds are not really Middle but Upper Cretaceous—or Thomson's (1919), that the immediately overlying flinty limestones bridge the interval between these "Utatúr" beds and the overlying chalky Danian (?) limestone, it would appear that a regression of the strand followed the deposition of these beds, and that the New Zealand area was emergent though quite unfolded during Cenomanian and Turonian times.

Upper Cretaceous.

As in New Zealand, so in the Malay Archipelago, the sea retreated early in the Cretaceous period and great orogeny followed, accompanied by the widespread intrusion of masses of peridotite, gabbro, and perhaps less basic rocks. The last remnant of the Tethyan sea was driven out from the region by these movements. Except for a few forms, the immigrant fauna appearing later in Cretaceous times was of the Indo-Pacific type (Martin, 1914). This Senonian transgression was much more widespread than that of Middle Cretaceous times. Though Van Es (1919) refers merely to the presence of basal Cretaceous rocks in Sumatra, Gregory (1916) mentions the occurrence of *Actinacis sumatraensis* here in Upper Cretaceous beds. Richarz (1910) has summarized the other occurrences of rocks of this age in this region. A small thin-shelled fauna has been found in west Borneo, but more noteworthy are the richly fossiliferous Senonian (Ariyalúr) beds of south-eastern Borneo, in which occur the rudistid *Radiolites* with *Ostrea*, *Trigonia*, *Nerinea*, *Strombus*, *Nautilus trinchinopolitensis*, *Acanthoceras*, *Scaphites*, and a few brachiopods. In Celebes the Upper Cretaceous beds, which apparently merge into the Tertiary, are known as the "Maroro formation." They consist of a generally unfossiliferous series of violet, grey-blue, yellow, or brown claystones, which are intensely folded and invaded by granite and other plutonic rock, by which they have been much metamorphosed. These are rather widespread on the west of the island, but on the east the corresponding beds are more marly in character, with radiolarite and foraminiferal limestone. Unfortunately, Wanner (1919) does not cite any palaeontological data concerning them. In Buru, Wanner found a small molluscan fauna with *Tissotia;* in Obi, the brachiopod *Trigonesmus;* and in the islets south-east of Misol "hard grey marls with banks crammed with large shells of *Inoceramus*," numerous rudistids, and, more rarely, echinoids. The foraminifer *Lacazina* and *Lithothamnium*, which were supposed to indicate the presence of Upper Cretaceous rocks in the Kei Islands, are, however, referred by Rutten (1914) to the Eocene. In the central part of northern New Guinea (the Torricelli Mountains, 142° E., 3° S.) Richarz (1910) has found a small fauna consisting of *Cardium productum* and *Cerithium* aff. *sociale* (forms which may extend down to the Cenomanian, but are also in the Upper Cretaceous series of the Alps, Gosau beds, and have allies in the Upper Cretaceous series of India), associated with indeterminate forms of *Protocardium*, *Venus*, *Tapes*, *Psammosolen*, *Ostrea*, and *Cypraea*, and with the foraminifera that appear to have Tertiary (Oligocene-Miocene) affinities. Richarz concludes that the whole series is of Upper Cretaceous age, but that it is a curiously provincial fauna, and in particular is unrelated to that in the south of New Guinea. Gregory and Trench (1916) have described the Upper Cretaceous (?) coral *Actinacis sumatraensis* from a limestone pebble obtained high up the Fly River with numerous others containing Eocene forms. Farther east, near Kerema (146° E., 8° S.), occur the supposedly Middle Cretaceous rocks with *Inoceramus*, *Gryphaea*, noted above. In New Britain there occurred an *Actonella* in a white chalky limestone containing *Globigerina* and other foraminifera, which, however, Brady referred to Recent species. In New Caledonia the St. Vincent series of beds were laid down with minor unconformity on the Eo-Cretaceous coal-measures. They contain *Acanthoceras* and *Douvilleiceras*, with *Kossmaticeras loganianum* and *K. cumshevaense*, which are found in the Middle Cretaceous rocks of Queen Charlotte Island (British Columbia). The last two forms are, however, also found

in the Senonian beds of Seymour Island, Graham's Land. together with *K. bhavani* and *Trigonia arctica,* which also occur in the St. Vincent beds, where is *Puzozia gaudana,* also found in the Senonian beds of Peru, Pondicherry, and South Africa, with other widespread Senonian genera not specifically identified ; nor does Piroutet (1917) discuss the affinities of the fauna, which, however, seems to be clearly representative of the general Indo-Pacific Upper Senonian fauna.

This fauna is also represented in New Zealand, spreading over the greater part of the North Auckland Peninsula. the eastern portion of the North Island, the northern and rather to the south of the central portion of the east coast of the South Island. The presence of *Gryphaea* and "Senonian" types of bryozoa in the Chatham Islands, as reported by



Dieseldorff (1901), may indicate an Upper Cretaceous transgression of the sea over the ancient land-mass of that region, but the information available does not permit us to decide whether the region remained continuously submerged until Middle Tertiary times, or whether some emergence of the land occurred in the interval, the late Cretaceous or early Tertiary times. The investigations of Woods (1917) on the fauna of the north-east of the South Island of New Zealand has shown that the general Indo-Pacific (Ariyalúr) Upper Senonian facies is clearly developed ; and this is confirmed by the later work of Trechmann (1918) and Wilckens (1917, 1920, 1922). Very striking, again, is the absence of any noteworthy community with the Australian Cretaceous fauna. Trechmann identifies some shells with the "*Natica*" *variabilis* of the Rolling Downs series, but Wilckens (1922) divides these into two new species.

The strong affinity between the contemporaneous fauna of New Caledonia and New Zealand is shown by the presence of the following common genera: *Kossmaticeras, Baculites, Lytoceras, Anisoceras, Gaudryceras, Trigonia, Arca, Cardium, Alaria.*

Very striking, however, is the close affinity of the New Zealand fauna with that of Graham's Land, Patagonia, Chile, and Peru. Woods (1917) recognized only two or three forms identical with South American species, and four with close affinities thereto. Trechmann (1917A) added to these, and Wilckens (1920, 1922), while revising some identifications, added a dozen species with close relatives among the South American beds. We may now recognize the following species of mollusca as being common to New Zealand and to Graham's Land and South America: *Trigonia hanetiana, Inoceramus pacificus, Panopea clausa, Baculites vagina, Kossmaticeras gemmatus.* In addition the following species in New Zealand are closely related to South American forms: *Cucullaea antarctica, C. zealandica, Malletia cymbula, Calliostoma thomsoni, C. wilckensi, Lahillia* sp., *Trigonia antarctica, T. pseudocaudata, Kossmaticeras haumuriensis, Natica ingrata, Scalaria pacifica, Struthiolariopsis similis, Eriptycha punamutica, Cylichna thomsoniana, Arrhoges haastianus,* Perissoptera waiparensis, Conchothyra parasitica, Tudicula* ex. aff. *tumida, Pleurotomaria maoriensis, Patella* (?) *amuritica, Cryptorhytis vulnerata.* Dr. Marshall's investigations of the fossils of the North Auckland Peninsula add further evidence of this affinity. So great is it that Wilckens (1920) concludes that New Zealand, Graham's Land, and Patagonia formed part of the southern coast of the Pacific Ocean in Senonian times.

There has thus been obtained within recent years strong palaeontological evidence of the littoral and therefore land connection of part of Australasia with Antarctica and South America at the close of Mesozoic times, a connection of which the probability has long been upheld by students of the distribution of the modern flora and fauna At the same time, the striking difference between the Cretaceous faunas of New Zealand and Australia indicates that at the close of Mesozoic times there was a marked difference between the relations of South America to New Zealand on the one hand and to Australia on the other, as has been the case, apparently, in succeeding periods up to the present.

Post-Cretaceous.

The circumpacific connection, however, broke down during the Tertiary period, but the stages by which the separation was affected will not be discussed here, though a few remarks may not be out of place. Divergence between the history of New Caledonia and New Zealand appears once more in Danian times. In the former, retreat of the sea occurred during this period, with some contemporaneous crust-folding occupying the early Eocene periods, after which a varied series of Eocene sediments were laid down in three stages, in the last of which the island was completely submerged. These contain *Spatangus, Prenaster*, and various species of *Orthophragmina* and *Lithothamnium*, the last two being genera well known in rocks of this age in New Guinea (Rutten, 1914). This transgression

* Trechmann thought this to be identical with *Aporrhais gregaria.*

was followed by the most intense orogenic movements of which there is record in the island, in which the vast intrusive masses of peridotite came into place. These movements were doubtless connected with those occurring in Miocene times throughout the outer arc of the Malay Archipelago which gave rise to intense folding and alpine overthrusting.* In New Zealand, on the other hand, the Senonian beds are followed by Danian (?) limestones, as suggested by Chapman's 1910 work, and these by a succession of Tertiary beds, for the most part without marked unconformity, though there is some evidence of block-movements, warping, and consequent local transgressions and regressions during that period. In the North Auckland Peninsula, however, the great dislocation of the Upper Cretaceous and early Tertiary beds, clay-stones, hydraulic limestones, &c. (into the latter of which the serpentines of Wade have been injected—*fide* Bartrum), contrasted with the lesser disturbance of the later Tertiary beds, suggests that this region has come within the influence of the New Caledonian early Tertiary orogenic movements. The abundant fauna exhibits but little community with that of the Tertiary rocks of southern Australia. In regard to the brachiopods, Thomson (1918) concludes that those in Australia, New Zealand, and South America originated on the coast of the portion of Gondwanaland that then existed, and were grouped into different faunal provinces by the early Cretaceous crust-movements, for in each area where Recent forms occur they are the diminished remnants of the "Miocene" forms in that area, and give no evidence of communication since that period with adjacent areas. "The communication between New Zealand and Antarctica and New Zealand with the migration of the brachiopods may have occurred as early as in the Cretaceous, and apparently was earlier than the connection of Antarctica with Australia." A like conclusion is reached by Marshall and Murdoch (1920), who state that "the present molluscan fauna of New Zealand seems to be a remnant of a fauna of early or middle Tertiary age." While, therefore, there is some indication of an influx of South American "Miocene" forms into New Zealand (when the New Zealand fauna was perhaps more allied to that of Patagonia than of Australia), it has been completely isolated ever since.

Thus it would appear as if at the close of Mesozoic times the various portions of Australasia ceased to have any striking unity of geological history. The fragmentation of the region became more active, and extending subsidence blocked it out into geographical elements, the remnants of which are now visible. These appear to have had very diverse histories during the Tertiary period, to have been submerged, warped, elevated, or folded at different times, and to have developed provincial faunas with little intermigration. Little has yet been done which permits us to correlate the Tertiary records in these various regions. The end of the Mesozoic period thus appears to be a fitting point to close this attempt to trace in broad outlines the geographical evolution of Australasia, and the source of its successive marine faunas.

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* A continuation of the same orogeny occurred throughout the archipelago at the close of Pliocene time, but was then chiefly in the nature of vertical block-movements, though with a considerable horizontal displacement also (Brouwer, 1919, 1921).

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Addendum.

Concerning the relationship of the "Permo-Carboniferous" fauna of Western Australia to that of the East Indies, reference should be made to the following paper read before the Royal Society of New South Wales in December, 1922, by Mr. W. S. Dun and Professor Sir Edgeworth David: "Notes on the Occurrence of *Gastrioceras* at the Irwin River Coalfield, Western Australia, and a Comparison with the so-called *Paralegoceras* from Letti, Dutch East Indies."

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ART. 2.—*The Genus* Glycymeris *in the Tertiary of New Zealand.*

By J. MARWICK, M.A., New Zealand Geological Survey.

[*Read, by permission of the Director of the N.Z. Geological Survey, before the Wellington Philosophical Society, 12th October, 1921; received by Editor, 2nd December, 1921; issued separately, 1st February, 1923.*]

Plates 1–7.

GLYCYMERIS Da Costa, 1778 (= PECTUNCULUS Lamarck, 1799).

THE genus *Glycymeris*, appearing first in the Cretaceous, is widely spread throughout the Tertiary strata of the world, and exists in the Recent seas of the West Indies, Britain, India, New Zealand, Australia, and western America. It is a shallow-water shell, ranging, according to Woodward, from 8 to 60 fathoms, and rarely to 120 fathoms. Consequently the fossil occurrence is generally in fine conglomerates, sandstones, or shell-beds.

Suter seems to have had an erroneous idea as to which is the anterior of the shell. Thus in his description of both *G. laticostata* and *G. modesta* (1913, pp. 851 and 852) he says the beaks curve "forward." This is not the case. The curvature, though generally slight, is towards the rear. It will not be out of place to quote Fischer (1887, p. 978): "The impression of the anterior adductor is subtrigonal, that of the posterior adductor is subtrapezoidal, and limited in front by a projection or ridge which is directed towards the umbones and more elevated than the ridge limiting the rear of the anterior adductor; the pallial line at its junction with the impression of the posterior adductor forms a small sinus; the beaks are slightly inclined to the rear."

Other noteworthy features are—

(1.) Worm-borings and malformation are very common on the posterior.

(2.) The ribs are narrower on the posterior.

(3.) In the *huttoni* group the anterior adductor impression is larger than the posterior.

(4.) In oblique shells the axis slopes downwards to the rear.

The earliest known occurrence in the New Zealand area is in the Upper Senonian. Mr. H. Woods (1917, p. 20) has recorded two species from this formation—*Pectunculus* sp. from the calcareous conglomerate of Amuri Bluff, and *P. selwynensis* from a slightly higher horizon at Selwyn Rapids. Another species, perhaps of Cretaceous age, is *Glycymeris concava* Marshall, from Wangaloa, a shell very like the Selwyn Rapids one, as noted by Dr. Marshall (1917, p. 459), but distinguishable by its much shallower anal depression. Then, too, the ribs of *G. selwynensis* are more strongly raised than those of *G. concava*, a feature seen only in well-preserved specimens. These early forms belong to the *huttoni* group (see below), differing only in their strongly-raised ribs and wide interstices. In this respect they approach the *laticostata* group, and may represent the ancestor

of those shells; but it seems more probable that the separation took place at an earlier stage than that of *G. selwynensis*.

The Tertiary species fall into three well-defined groups:—

I. The *laticostata* group, characterized by—

(*a*.) Raised rounded ribs (a few exceptions).
(*b*.) An equilateral outline, circular to dorso-ventrally oval.
(*c*.) Closely set ligamental grooves on a highly inclined area.
(*d*.) Valves little inflated, beaks low (exceptions).
(*e*.) Teeth small and numerous until invaded by the area.

II. The *huttoni* group, characterized by—

(*a*.) Linear interstices between low, flat ribs (exceptions).
(*b*.) An inequilateral outline, subquadrate to obliquely ovate.
(*c*.) Well-spaced ligamental grooves on a moderately inclined area.
(*d*.) Valves inflated, beaks prominent.
(*e*.) Teeth large and strong.

Some specimens of this group present an external resemblance to *Cucullaea*, but they can always be recognized by their rounded shoulders.

III. The *Axinea* group, characterized by—

(*a*.) Almost smooth surface, under a lens showing very fine radial riblets over the whole disc, superimposed upon a system of narrow obsolete ribs corresponding to the fine crenulations on the inner margin. Sometimes these ribs are shown only on weathering.
(*b*.) Outline circular to ovate.
(*c*.) Many closely set ligamental grooves on a highly inclined area.
(*d*.) Valves inflated, beaks moderate.
(*e*.) Teeth numerous and fine.

The fine secondary riblets so well developed in this group often appear in other groups, but then only on a small portion of the disc.

This group corresponds to *Axinea* of Poli, 1791, used as a separate genus by Cossmann, Angas, and others; as a section of *Glycymeris* by Fischer and Adams, and as a synonym of it by Zittel, Dall, and Suter.

The three divisions of the New Zealand species are probably of subgeneric value, the first being *Glycymeris* s. str., the second a new subgenus, and the third *Axinea*. The definite classification into subgenera has not been carried out in this paper, as no specimens from abroad were available for comparison.

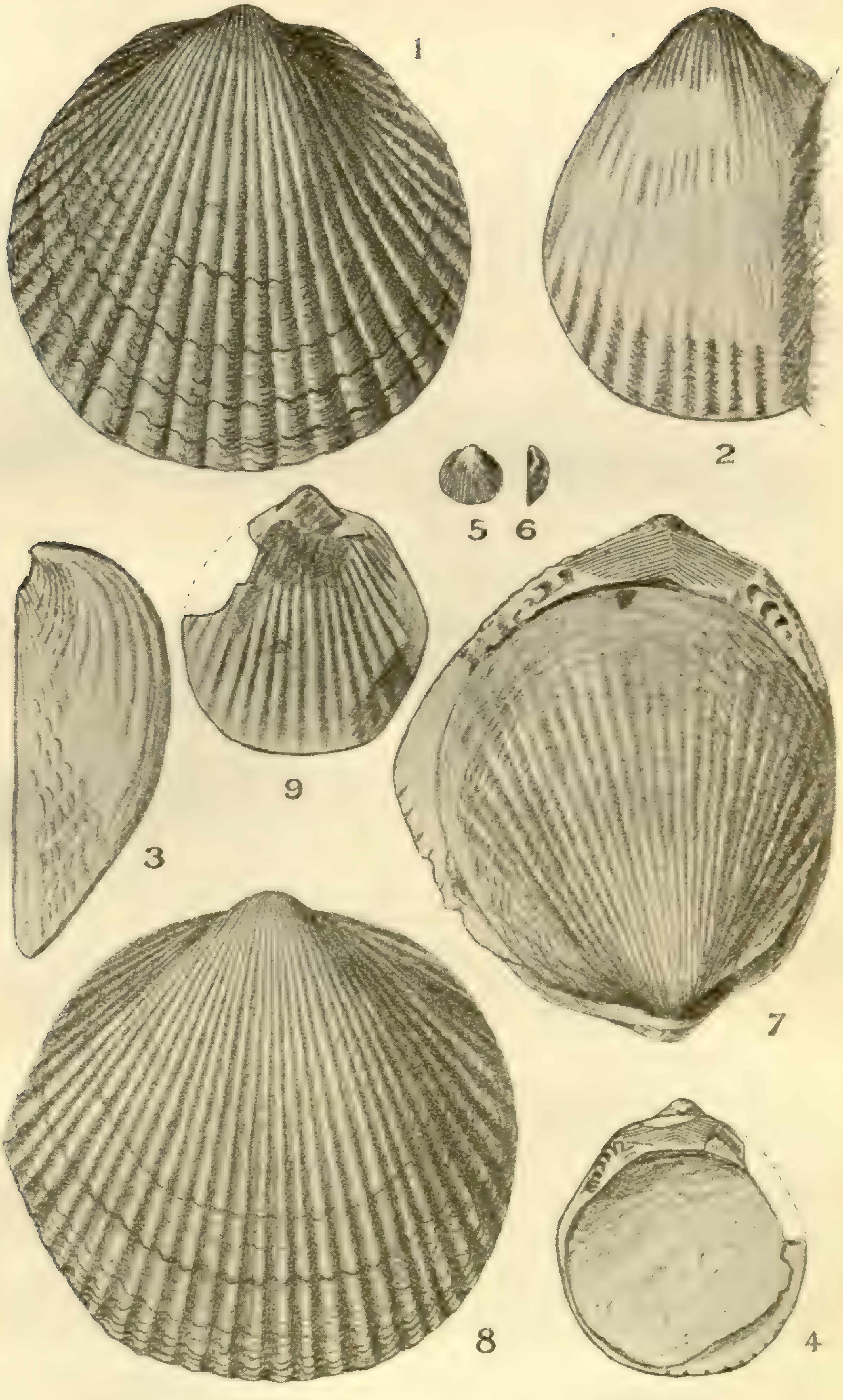
Description of Species.

I. The *laticostata* Group.

Glycymeris laticostata (Quoy and Gaimard). (Plate 1, fig. 1.)

For synonymy and description see Suter's *Manual*, 1913, p. 851.

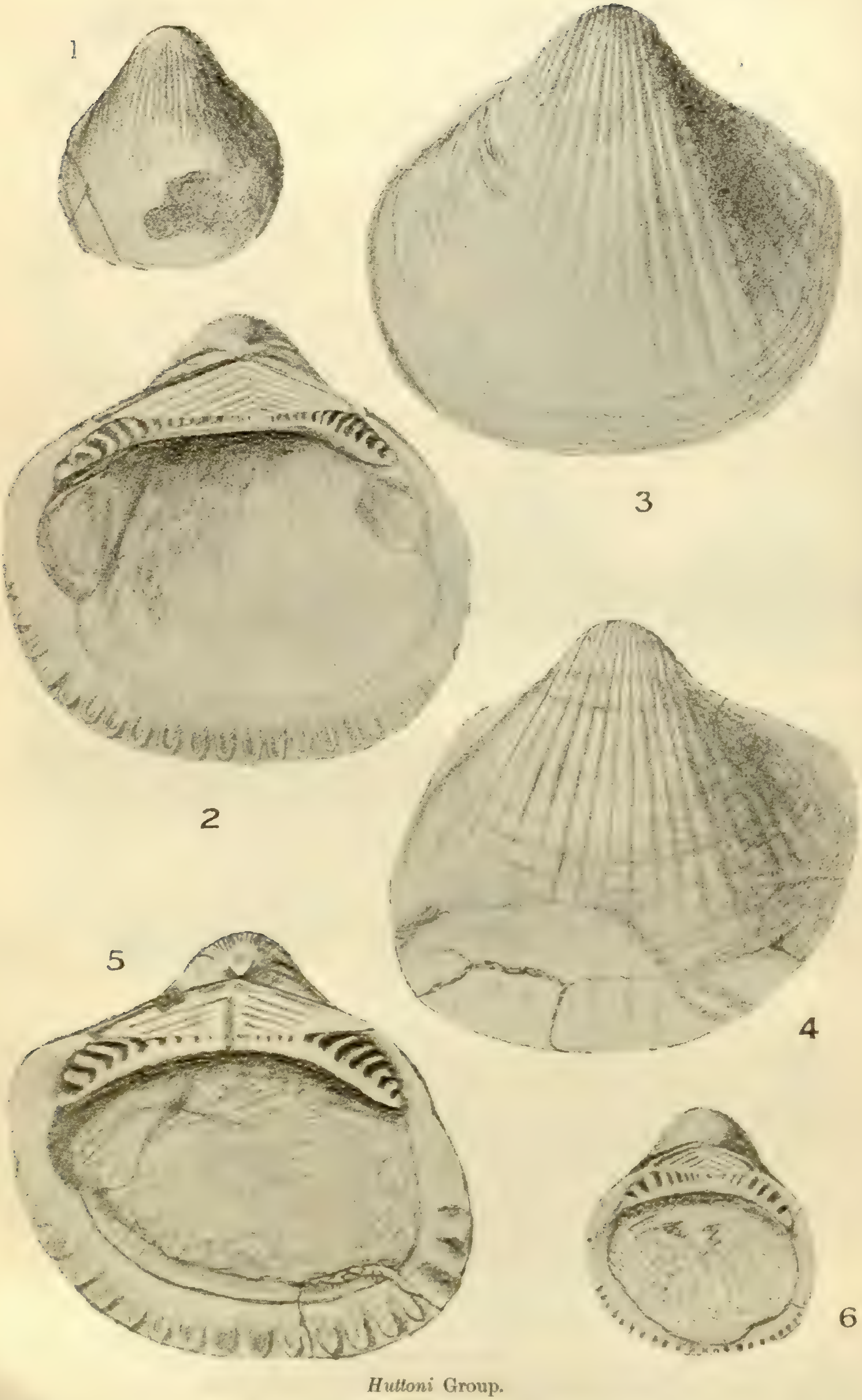
A noteworthy feature that has not been remarked upon previously is the difference of the ribbing between the anterior and posterior halves of the shell. The ribs on the latter are narrower and more rounded, and the interstices are wider than those of the former.



Laticostata Group.

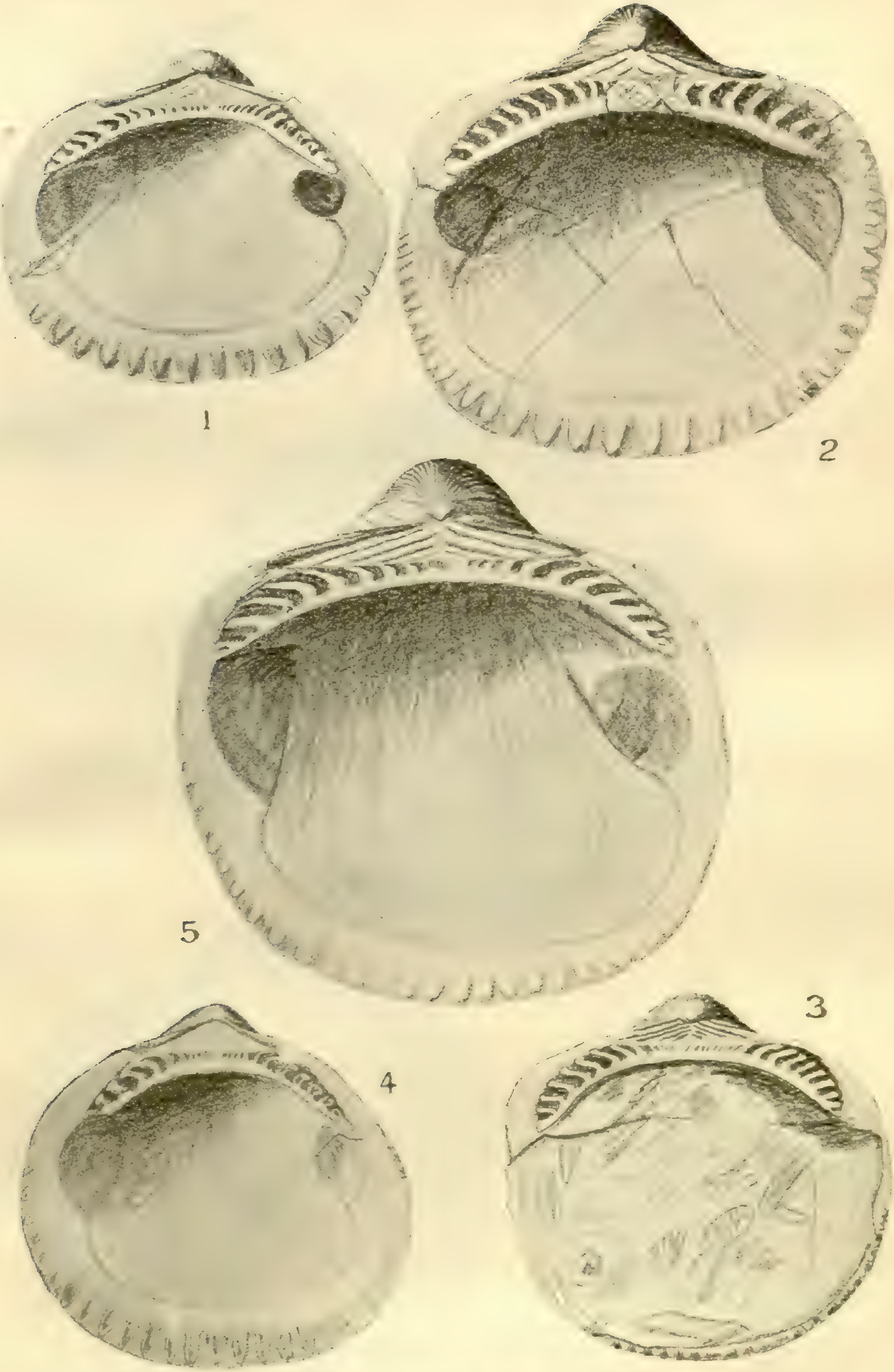
FIG. 1.—*Glycymeris laticostata* (Q. & G.), right valve.
FIGS. 2, 3.—*Glycymeris* sp. A. (Uruti.)
FIGS. 4, 9.—*Glycymeris lornensis* n. sp. Holotype.
FIGS. 5, 6.—*Glycymeris* sp. B. (Pakaurangi.)
FIG. 7.—*Glycymeris chambersi* Marshall. Holotype.
FIG. 8.—*Glycymeris traversi* (Hutton). Lectotype.

Face p. 64.]



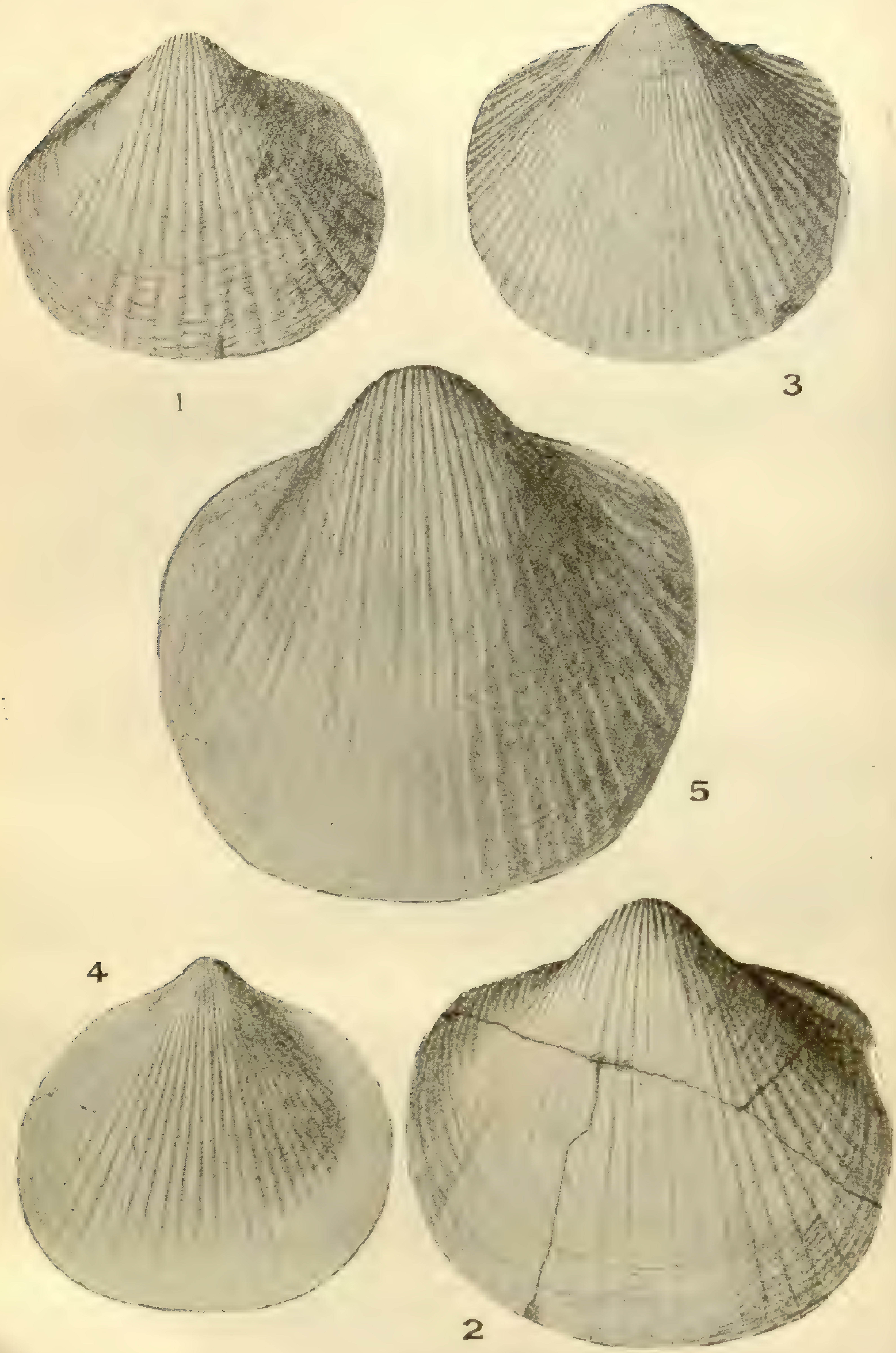
Huttoni Group.

FIGS. 1, 6.—*Glycymeris cordata* (Hutt.). Lectotype.
FIGS. 2, 3.—*Glycymeris kaawaensis* n. sp. Holotype.
FIGS. 4, 5.—*Glycymeris hurupiensis* n. sp. Holotype.



Huttoni Group.

FIG. 1.—*Glycymeris rapanuiensis* n. sp. Holotype.
FIG. 2.—*Glycymeris huttoni* Marwick. Lectotype.
FIG. 3.—*Glycymeris subglobosa* Suter. Holotype.
FIG. 4.—*Glycymeris managaensis* n. sp. Holotype.
FIG. 5.—*Glycymeris robusta* n. sp. Holotype.



Huttoni Group.

FIG. 1.—*Glycymeris rapanuiensis* n. sp. Holotype.
FIG. 2.—*Glycymeris huttoni* (Hutt.) Marwick. Lectotype.
FIG. 3.—*Glycymeris subglobosa* Suter. Holotype.
FIG. 4.—*Glycymeris manaiaensis* n. sp. Holotype.
FIG. 5.—*Glycymeris robusta* n. sp. Holotype.

Axinea Group.

FIG. 1.—*Glycymeris callaghani* n. sp. Holotype.
FIG. 2.—*Glycymeris waitakiensis* n. sp. Holotype.
FIG. 3.—*Glycymeris shrimptoni* n. sp. Holotype.
FIG. 4.—*Glycymeris trelissickensis* n. sp. Holotype.
FIG. 5.—*Glycymeris waipipiensis* n. sp. Holotype.
FIG. 6.—*Glycymeris modesta* (Angas). Left valve.

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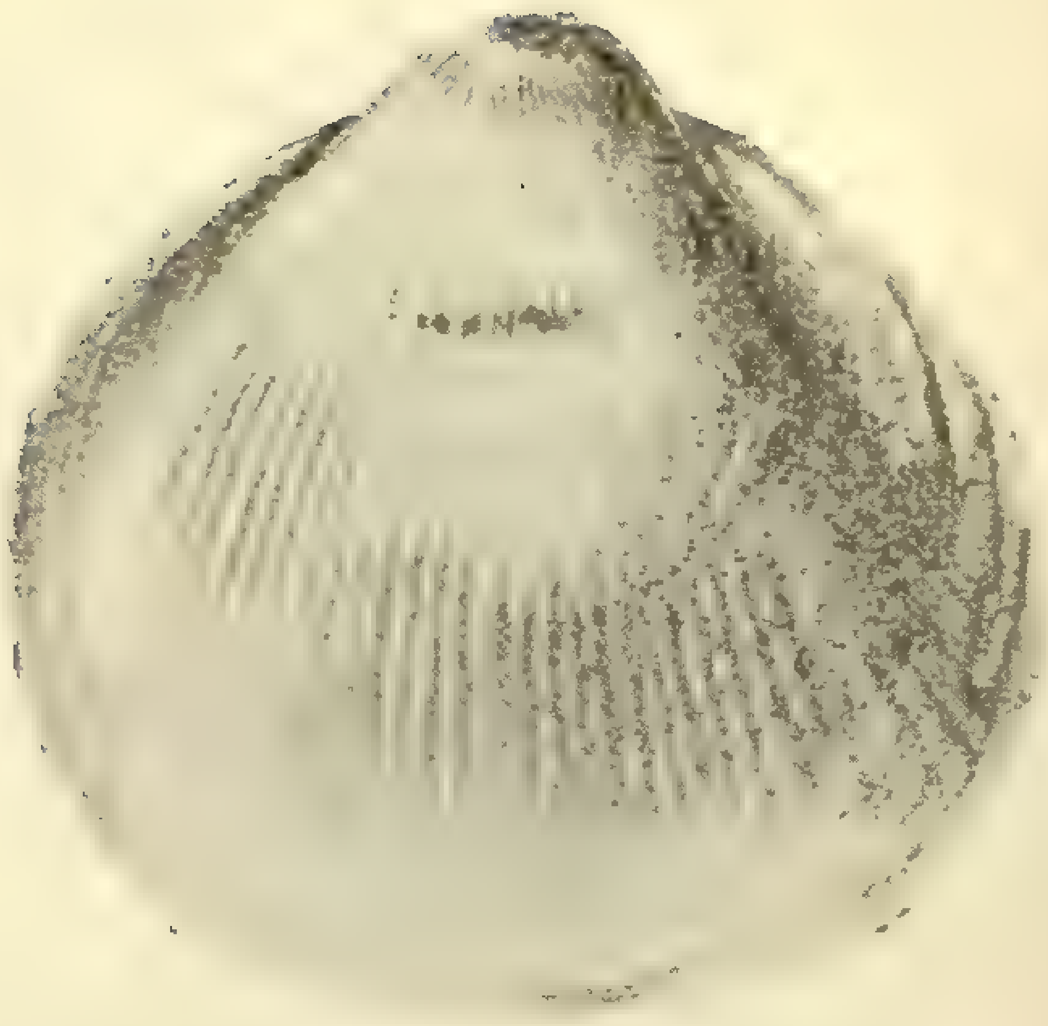

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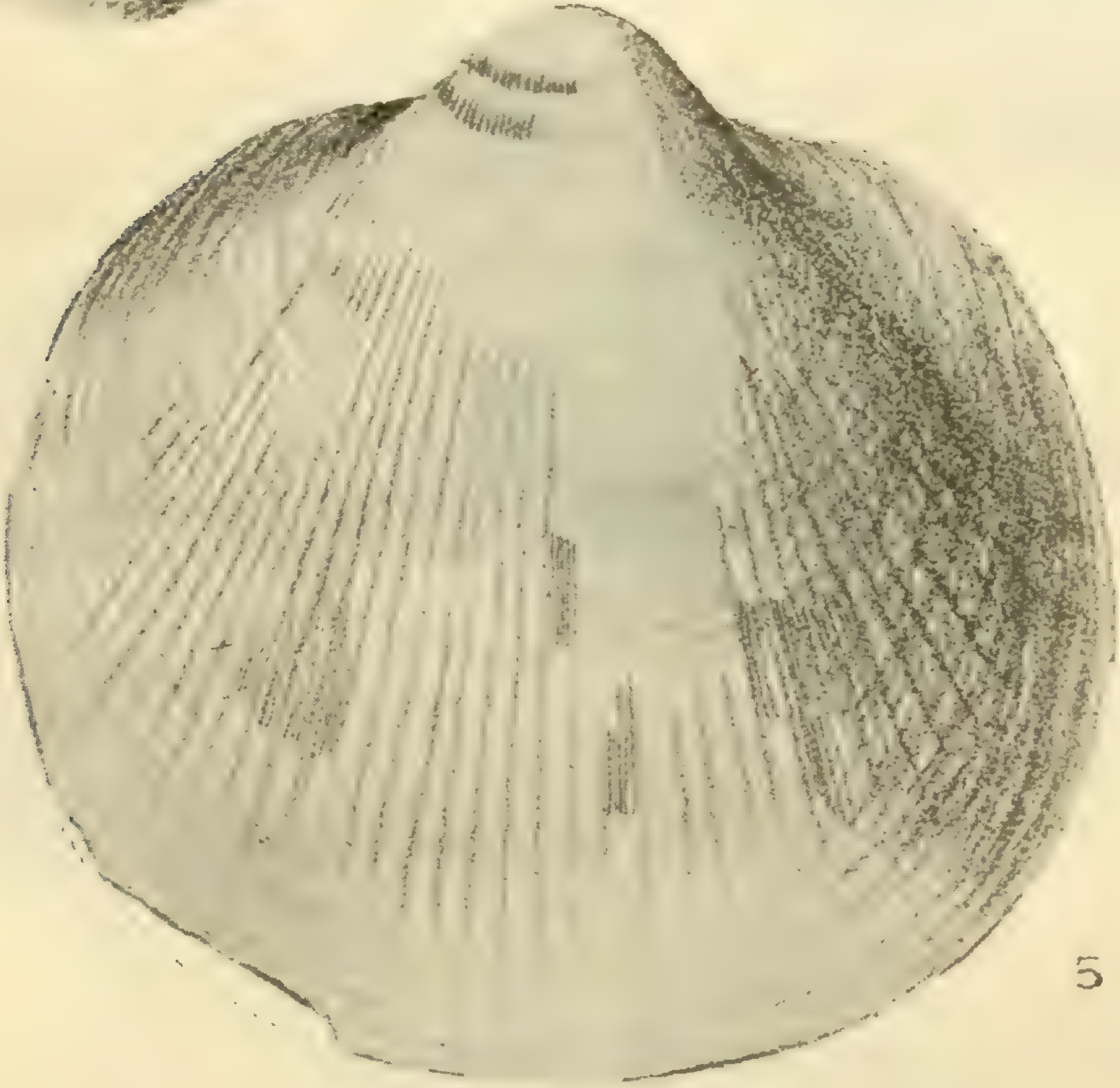

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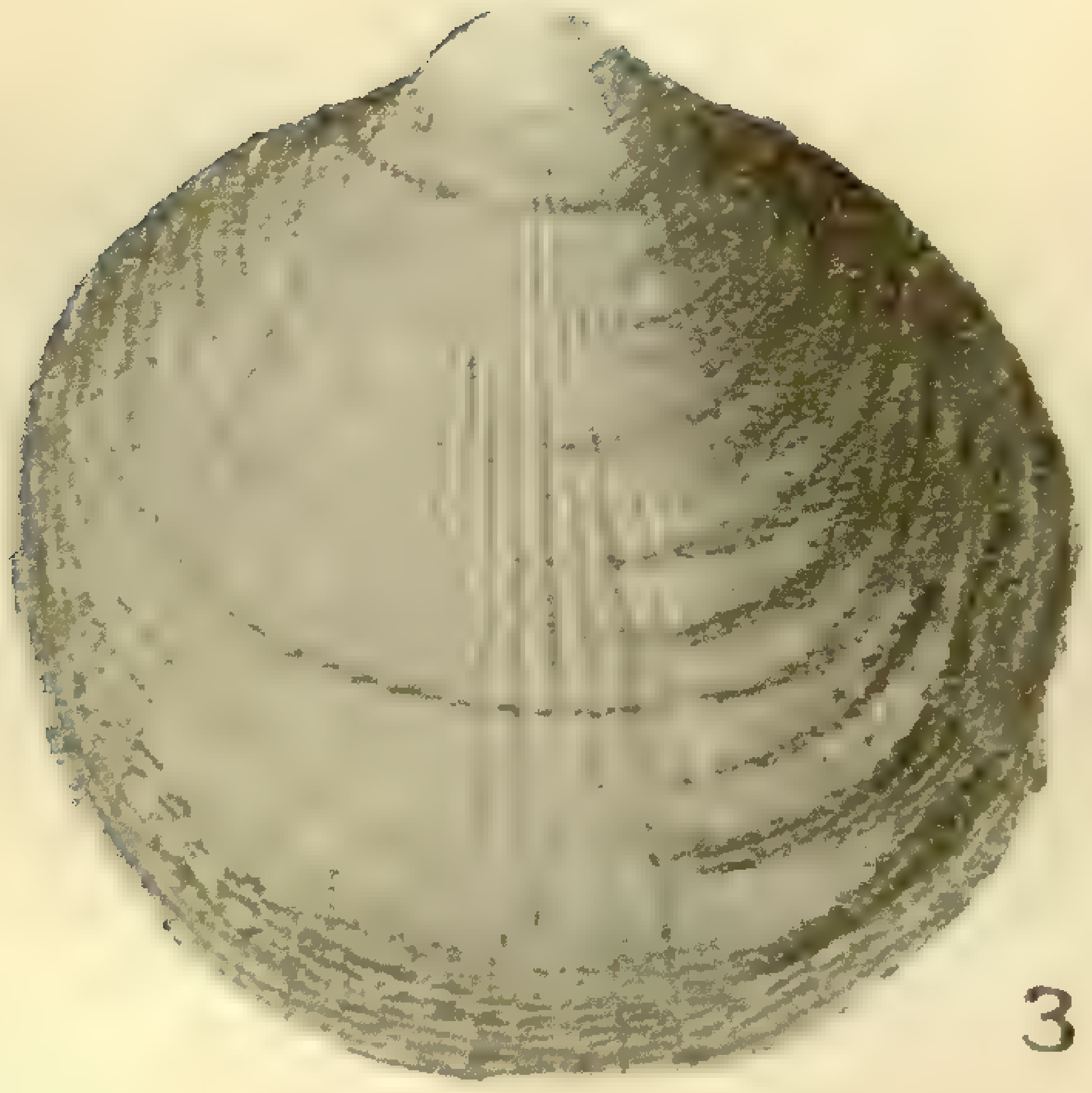

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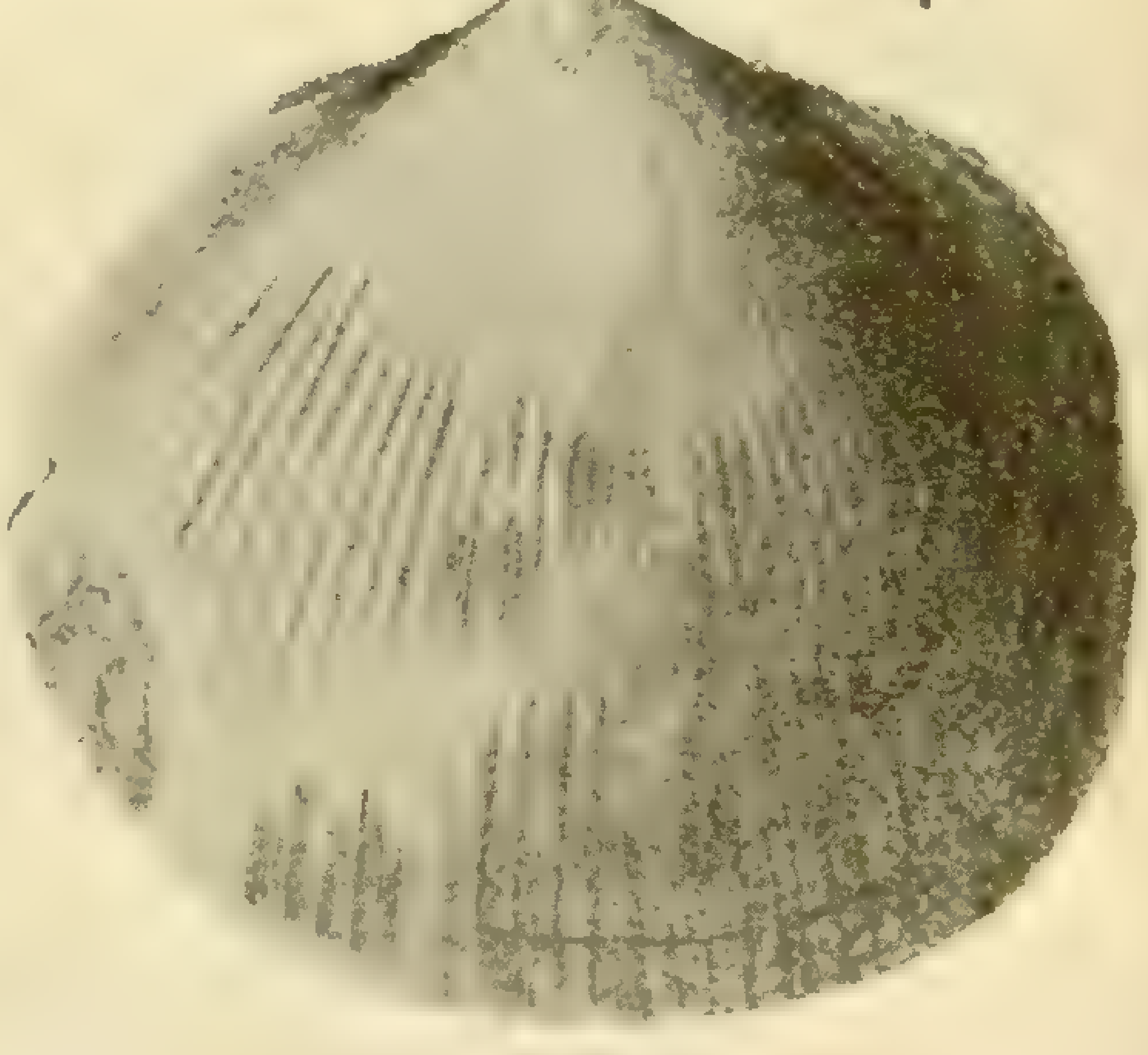

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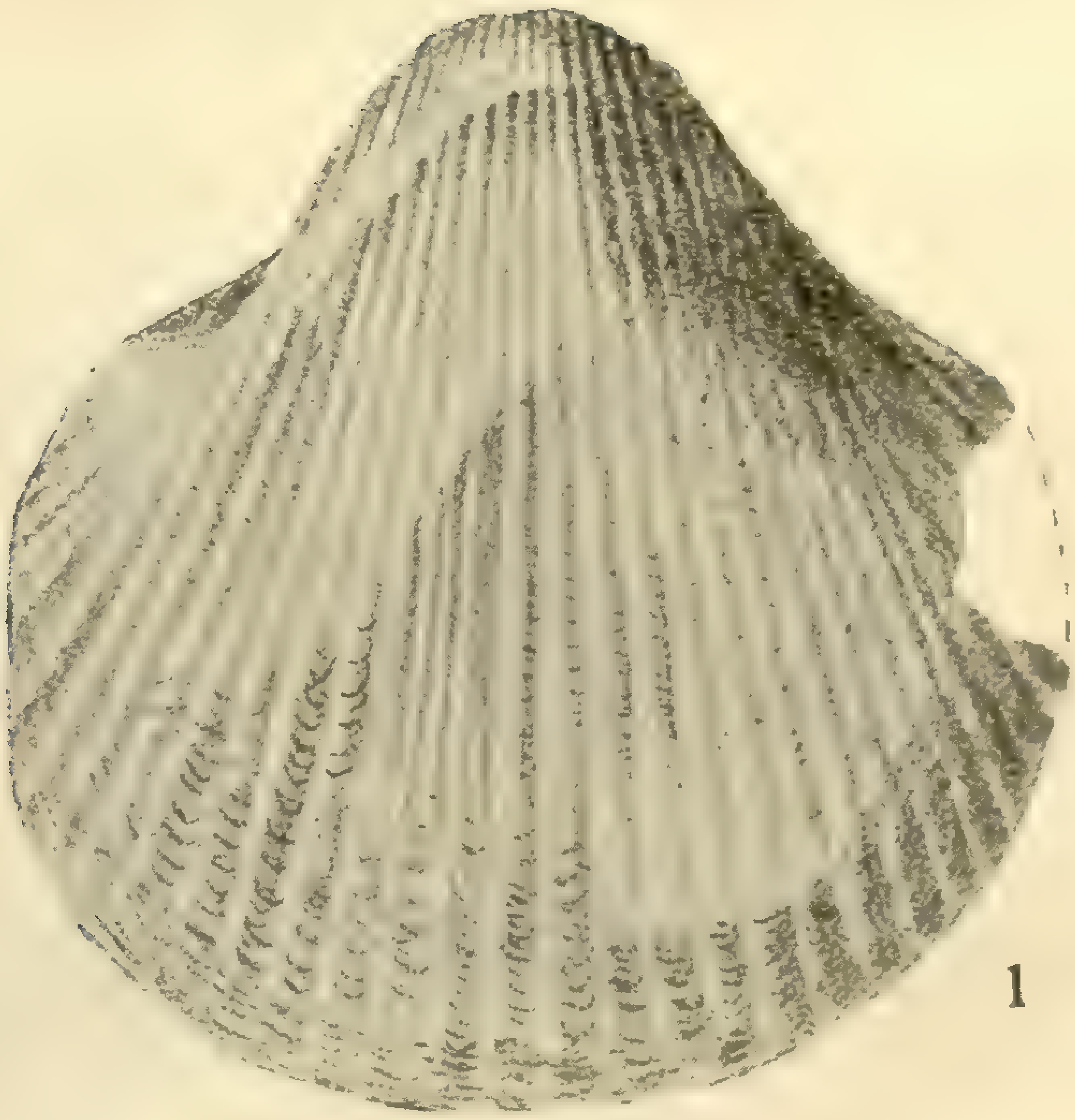
Axinea Group.

Fig. 1.—*Glycymeris callaghani* n. sp. Holotype.
Fig. 2.—*Glycymeris waitakiensis* n. sp. Holotype.
Fig. 3.—*Glycymeris shrimptoni* n. sp. Holotype.
Fig. 4.—*Glycymeris trelissickensis* n. sp. Holotype.
Fig. 5.—*Glycymeris waipipiensis* n. sp. Holotype.
Fig. 6.—*Glycymeris modesta* (Angas). Left valve.



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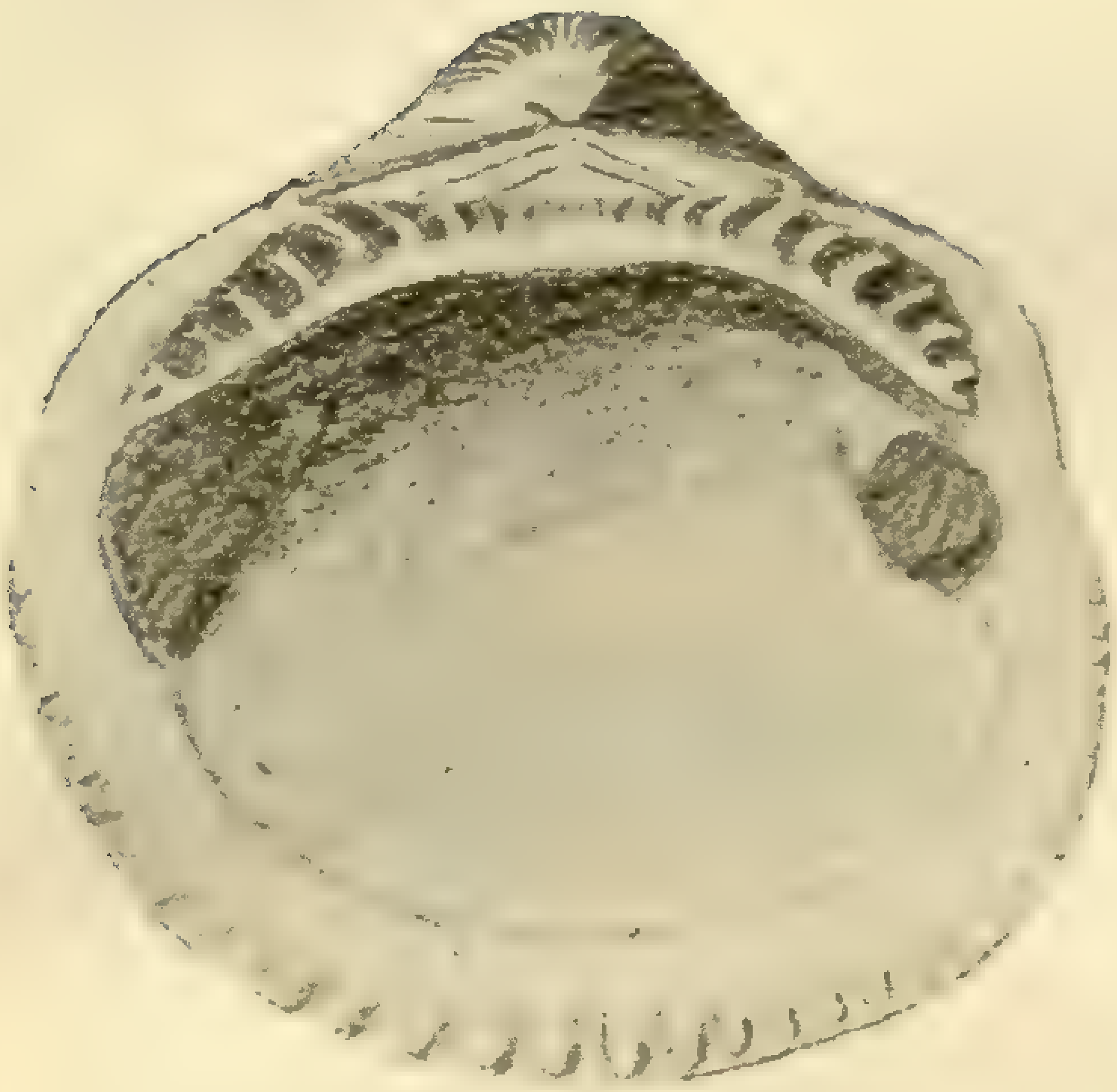

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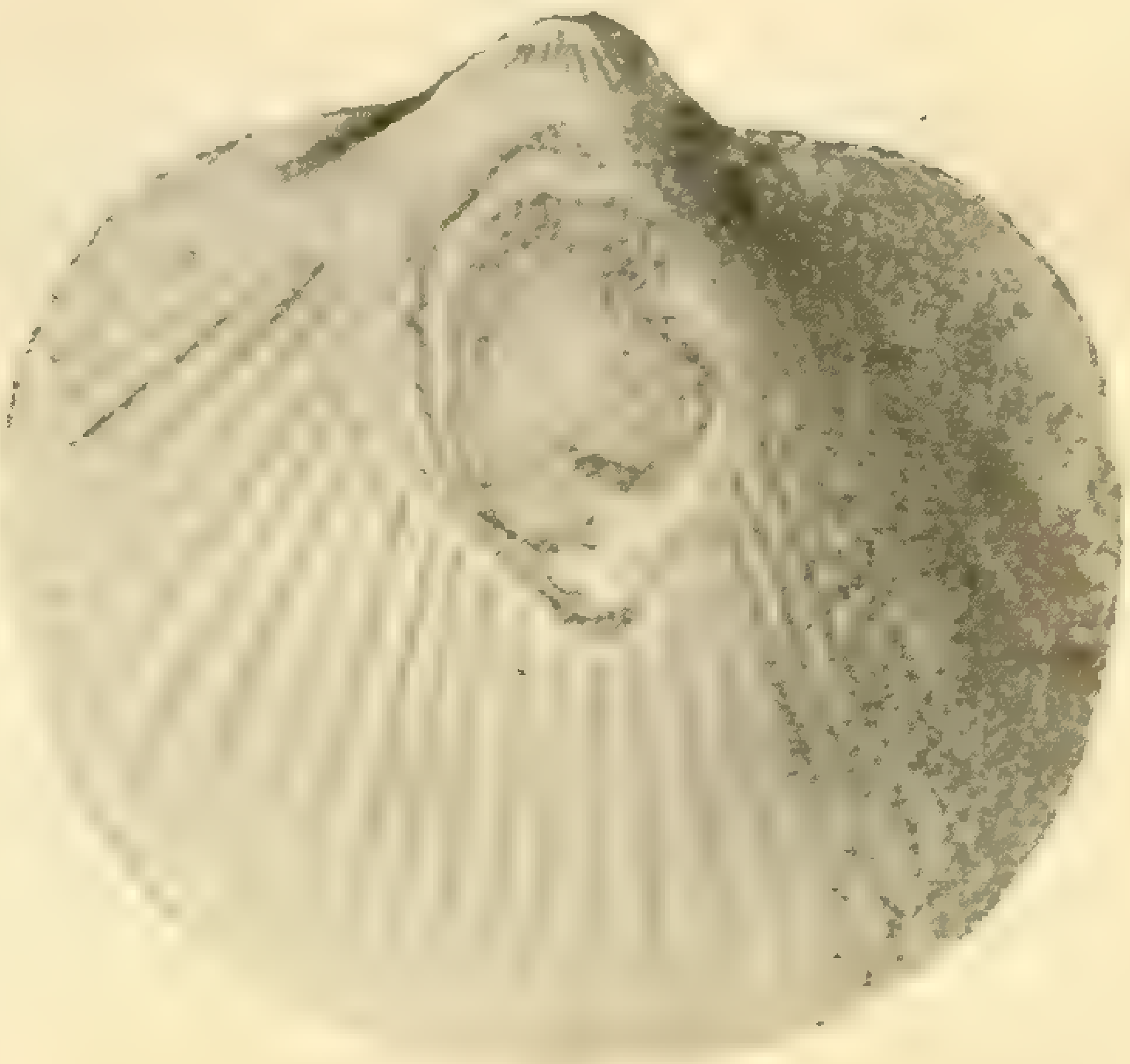

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Huttoni Group.

Figs. 1, 4.—*Glycymeris concava* Marshall var. (Wangaloa.)
Fig. 2.—*Glycymeris huttoni* Marwick. (White Rock River.)
Fig. 3.—*Glycymeris* sp. (Akuaku.)

Localities :—

Holotype, Recent.
206—Shakespeare Cliff, Wanganui.
Castlecliff, Wanganui (Marshall).
Waihi, near Hawera (Marshall and Murdoch).
749 (in part)—Mouth of Ruamahanga River, Palliser Bay. (Fragment.)
81—Castle Point. (Shell slightly more globose, ribs more regular.)
231—McLean's, Ngaruroro River, Hawke's Bay. (An old, heavy shell, with beak and ribs like the Castle Point shells.)
Tokomaru (Marshall). (A very worn specimen, but similar to those from Castle Point.)
? 649—Paparoa Rapids, Wanganui River. (One imperfect specimen.)
? 786—Mount Donald, Weka Pass. (An imperfect specimen, more inflated than usual: *Pal. Bull. No. 8*, p. 42, last list.) This specimen resembles that from loc. 231.
? 246—Cape Rodney, Auckland. (A distorted specimen.)

The locality-numbers are those of the New Zealand Geological Survey (see *N.Z. Geol. Surv. Pal. Bull. No. 1*).

It will be noted that positive identification could not be made in the last three localities. The shells are undoubtedly of this group, but may represent different species.

McCoy (1875, p. 26, pl. xix, figs. 9–13) has described and figured specimens attributed to this species from the "Lower Tertiary" of Bird Rock, Geelong; Mount Eliza and Mount Martha, at Schnapper Point. With reference to this, Tate (1885, p. 137) says, "The identification of the fossil and the living species has been disputed by Mr. R. M. Johnston. The material at my command is not sufficient to permit me to express an opinion, though I have little hesitation in accepting Professor McCoy's determination in respect to the fossil represented by fig. 10."

Unfortunately, no material from Australia was available for this paper, and opinions based upon figures and descriptions are not so reliable as those based on the actual specimens. However, the excellent figures of the *Prodromus* show no difference between the anterior and posterior ribbing, so the specific identity of the two shells is open to doubt.

Records to be eliminated from *N.Z. Geol. Surv. Pal. Bull. No. 8* :—

Page 25. Manaia Beach. These shells belong to the *huttoni* group, and are here placed as a new species = *G. manaiaensis*.
Page 30. Lower Awatere, loc. 126 = *G. manaiaensis*.
Page 31. Starborough Creek = *G. manaiaensis*.
Page 40. Moonlight Creek = *G. manaiaensis*.
Page 44. Motunau beds, Weka Pass = *G. manaiaensis*.
Page 45. Motunau beds, Weka Pass = *G. manaiaensis*.
Page 45. Motunau beds, Weka Pass = *G. manaiaensis*.
Page 45. Motunau beds, Lower Waipara = *G. manaiaensis*.
Page 46. Motunau beds, Mid-Waipara = *G. manaiaensis*.
Page 53. Kakahu = *G. subglobosa* (distorted).
Page 57. Pareora, loc. 458 = *G. huttoni* (worn).
Page 59. White Rock River, loc. 165 = *G. huttoni* (worn).
Page 85. Bed K, tuffs south of Cape Wanbrow = *Venericardia* sp. (common in this locality).

In the cases cited above, as well as in the rest of this paper, the specimens have actually been handled. In the case of many other occurrences noted by Suter the specimens are missing from the Geological Survey collections; in fact, *no undoubted specimen of* G. laticostata *has been seen from strata older than Wanganuian.*

Cardium brachytonum Suter.

N.Z. Geol. Surv. Pal. Bull. No. 5, p. 17, pl. x, fig. 5, 1917.

The holotype on examination proves to be the cast of a *Glycymeris*, probably *laticostata*. In the plate reproduced in *Bulletin No. 5* the extremities of the hinge-area have been blocked out by a black background.

Glycymeris traversi (Hutton). (Plate 1, fig. 8.)

1873. *Pectunculus traversi* Hutton, *Cat. Tert. Moll.*, p. 28.
1914. *Glycymeris traversi* (Hutton): Suter, *N.Z. Geol. Surv. Pal. Bull. No. 2*, p. 35, pl. iv, figs. 2*a*, 2*b*.

In his description Suter gives the locality of the lectotype as Chatham Islands. The actual specimen in the Dominion Museum is labelled "Loc. ?" However, the shell is almost certainly from Chatham, so Suter's statement may stand.

Buchanan's drawing of this shell, reproduced by Suter (see above), does not represent accurately the wide interstices between the ribs. From the drawing one would take the shell to be inseparable from *G. laticostata*; this, however, is not so. The interstices are equal in width to the ribs, even at the margin of a $2\frac{3}{4}$ in. shell; thus the ribs in *G. traversi* are noticeably narrower than in *G. laticostata*. As to Suter's statement that the former is less inflated than the latter, the present examination does not bear out the observation. The inflation is practically the same in shells of equal size. There is very little difference in width between the anterior and posterior ribs.

The shell from loc. 786, Mount Donald, in this paper provisionally placed under *G. laticostata*, may be the same as the one from Weka Pass placed under *G. traversi* by Hutton (1873, p. 28). If so, Hutton's record of this species from that locality must be deleted, as the specimen in question has broadly rounded ribs, and so is nearer *G. laticostata*. No specimen of *G. traversi* from New Zealand rocks has been seen during this examination, nor can I find a record of its having been identified by Suter.

Glycymeris lornensis n. sp. (Plate 1, figs. 4, 9.)

Shell medium-sized, suborbicular to longitudinally oval, equilateral; beaks only moderately raised above the dorsal margin, which is short; anterior end convex, the dorsal margin sloping; posterior end similar; sculpture consisting of 25 to 30 rounded, radiating ribs which reach the margin but become obscured in some specimens by strong growth-lines, the interstices rounded and narrower than the ribs; margins weakly crenate; hinge-plate deeply encroached on by the ligamental area, even in small individuals, leaving three or four teeth on each side; ligamental area relatively large, steeply inclined, and very closely grooved by about 12 well-incised lines.

Holotype in collection of N.Z. Geological Survey.

Height, 40 mm.; length, 40 mm.; thickness, 14 mm. (one valve).

Material.—Six specimens, none of which is perfect.

Locality.—Conglomerate band in Waiarekan tuffs about 50 ft. below the diatomaceous ooze, 400 yards west of Lorne Railway-station, North Otago. (J. Marwick.)

The actual specimens are from an outcrop above the road near the base of the hill, apparently a slip from above.

This shell has a more prominent beak than *G. laticostata*; it is also much smaller; so that young individuals of the latter may be distinguished by their little-developed ligamental area. In most specimens there is an inclination towards a subtriangular shape, and very little difference of width between the posterior and anterior ribs.

Glycymeris chambersi Marshall. (Plate 1, fig. 7.)

1909. *Glycimeris chambersi* Marshall, *Subantarctic Islands of N.Z.*, vol. 2, p. 701.

1915. *Glycymeris laticostata* (Q. & G.): Suter, *N.Z. Geol. Surv. Pal. Bull. No. 2*, p. 49.

Suter thought that this shell was the ovate form of *G. laticostata*, but several features are displayed which seem to warrant the preservation of Marshall's specific name. The most important is that the area is more densely striated than that of *G. laticostata*, there being 13 striae in an area 7 mm. wide, while an equal area of *G. laticostata* has only about 7. In addition, the rib-interstices on the middle of the disc are deeper, and the shoulders are inclined to be narrower and more rounded.

The type-material consists of a pair of valves (one of which is incomplete), enclosing a larger right valve; the heights are 56 mm. and 62 mm. respectively. From the great encroachment of the area on the teeth, the latter appears to be a fully-grown shell.

This species seems to be intermediate between *G. lornensis* and *G. laticostata*; it is nearer to these than to *G. traversi*.

Locality.—Campbell Island.

Holotype in School of Mines collection, Otago University.

Species not good enough for Full Description.

Glycymeris sp. **A.** (Plate 1, figs. 2, 3.)

From loc. 1041, Uruti, North Taranaki.

Mr. L. I. Grange collected a shell of this group which, from its trigonal shape, wide ribs, and great inflation, especially towards the beaks, must be classed as a new species. The imperfect state of the specimen, however, makes it advisable to withhold full specific designation.

Glycymeris sp. **B.** (Plate 1, figs. 5, 6.)

From Pakaurangi Point, Kaipara (Bartrum).

This very small shell, of only 8 mm. height, has a thickness (one valve) of 3 mm., and so is much too inflated to be the young of any of the named species. It is not necessarily a young shell. Until this point is settled by the collecting of more specimens, specific description and naming had better be held over.

Shells with Sculpture unusual for the Group.

Glycymeris sp. C.

In the Otago University Mining School collection there is a double-valved specimen, 60 mm. high and 55 mm. long, from an unknown locality. It is dorso-ventrally oval, equilateral, and has a closely-lined area. The sculpture, consisting of 40 flat obsolete ribs with linear interstices, is unusual for this group. The beaks are only moderately raised above the dorsal margin, but they are broad and prominent, the whole shell being considerably inflated. In the absence of a locality it would be unwise to give the shell a specific name.

From a shell-bed about the horizon of the Wairarapa limestone, Pukenui, south of Martinborough, the author collected the top half of a valve some-similar to sp. C, but larger and flatter.

II. The *huttoni* Group.

Glycymeris huttoni nom. mut. (Plate 3, fig. 2; Plate 4, fig. 2; Plate 7, fig. 2.)

1873. *Pectunculus globosus* Hutton, *Cat. Tert. Moll.*, p. 28 (not of Sowerby).

1897. *Pectunculus globosus* Hutton: Harris, *Cat. Tert. Moll. Brit. Mus.*, p. 343.

1914. *Glycymeris globosa* (Hutton): Suter, *N.Z. Geol. Surv. Pal. Bull. No. 2*, p. 35, pl. iv, figs. 1*a*, 1*b*, 1*c*.

"*Globosa*" is preoccupied by J. Sowerby in Dixon's *Geol. of Sussex*, p. 170, t. 3, fig. 20, 1850, so, unfortunately, this well-known name must go.

Hutton gives as the localities of his species "Hicks Bay; Kokohu; Wairoa, Nelson; Kanieri; Motunau (L); Broken River (U); Callighan's Creek; Kawau; Oamaru." Unfortunately, the lectotype fixed by Suter is the only specimen available from Kanieri, so there are no means of finding out what variations existed in that locality. Nor are there any other of Hutton's types preserved. A consideration of the other localities does not help us very much:—

(*a.*) There are now no specimens of *Glycymeris* from Hicks Bay, either in the Geological Survey collection or at the Dominion Museum. Harris (1897, p. 343) mentions "as immense double-valved specimen" from this locality. This description suits the shell (locality unknown) which was thought by Suter to be the type of *Cucullaea ponderosa*, and which is here classed as *G. robusta* (see below).

(*b.*) Kokohu (= Kakahu): Suter separated these shells as *G. subglobosa*.

(*c.*) Wairoa, Nelson: Of a large number of specimens in the Geological Survey collection, all belong to *G. cordata*. Perhaps Hutton mistook a large specimen of this for his *G. globosa*.

(*d.*) Motunau (L): The exact locality is uncertain, but the few poor specimens in the Motunau collections (locs. 218 and 219) are here referred to *G. manaiaensis*.

(*e.*) Broken River (U) affords good specimens, which are, however, more oblique than the type.

(*f.*) Callighan's (= Callaghan's) Creek: The common shell of this locality belongs to the *Axinea* group, and is here called *G. callaghani*. There is another shell of the *huttoni* group, but from the equilateral and regularly-rounded shape in youth, and the absence of an anal sinus, it is considered to belong to a different species.

(*g.*) Kawau : No specimens very near the type were seen.

(*h.*) Oamaru : The many fossiliferous localities in this district and the various horizons represented give Hutton's use of the name a very wide meaning. The Target Gully " shell-bed " was unknown to him, and, as he used " Awamoa " as a separate locality, it is hard to say from where his specimens came.

Thus it will be seen that there is room for considerable doubt as to the exact limits assignable to this species. The shells from the upper beds at Broken River, though more oblique than the Kanieri one, have the same strong anal sinus. Specimens similar to the Broken River ones are common at White Rock River, Pareora, and these, principally, were used in this paper for comparative purposes (see Plate 7, fig. 2).

Localities :—

Kanieri. (Lectotype.)

165—White Rock River, Pareora. (Also a flat variety in Otago Museum collection.)

458—Lower Gorge, Pareora River.

237—" Upper part of Mount Brown limestone, Trelissick."

451A—Pareora beds, Thomas and Porter Rivers.

Lower Gorge, Waipara (Marshall). (Shells more oblique and with sloping shoulders; perhaps a new species.)

Muddy Terrace, Waikaia (Marshall).

Opihi River, South Canterbury (north bank, two miles west of Pleasant Point) (Marwick).

Grey Marls, Mead Gorge, 25 ft. below conglomerate (Thomson).

Tutamore Ridge, Poverty Bay district (Ongley and Macpherson).

Shingly Creek, Lake Heron (Canterbury Museum collection: two specimens, one with a high, sharp beak).

Records to be eliminated from *N.Z. Geol. Surv. Pal. Bull. No. 8* :—

Page 23. Onairo = *G. manaiaensis.*

Page 45. Motunau beds, Weka Pass = *G. manaiaensis.*

Page 48. Trelissick Basin, loc. 239 = *G. trelissickensis.*

Page 49. Trelissick Basin, loc. 449 = *G. trelissickensis.*

Glycymeris subglobosa Suter. (Plate 3, fig. 3; Plate 4, fig. 3.)

1917. *Glycymeris subglobosa* Suter, *N.Z. Geol. Surv. Pal. Bull. No. 5*, p. 66, pl. vii, fig. 8.

For the description of this species Suter used, in addition to the Kakahu material from which he chose his holotype, a paratype from Target Gully. This latter shell belongs to a different species (*G. robusta* n. sp.), and has been responsible for such features as " more inflated than *globosa* " and " secondary ornamentation on the ribs " in Suter's description.

The number of ribs on the holotype is 56, but other specimens have as few as 48. This species is distinguishable from *G. huttoni* by its somewhat rounded ribs and interstices. In this feature (seen only in well-preserved samples) it resembles the Cretaceous species—an interesting fact when its low stratigraphical position in the Tertiary is remembered. The angle of the beak is wider than that of *G. huttoni*, the anal depression is not so marked, and the outline is more nearly equilateral.

Localities :—

164—Kakahu. (Holotype.) (Also in Dr. Marshall's collection.)

176—Black Point. (Poor specimens.)

Although this shell has been recorded from many horizons—as high, indeed, as Wanganuian—these determinations must be considered extremely doubtful. No specimens examined from other than the two localities given above can be placed in this species.

Glycymeris robusta n. sp. (Plate 3, fig. 5; Plate 4, fig. 5.)

Shell very large, heavy, much inflated, subquadrate; beaks very prominent; anterior dorsal margin long, curved, descending gradually; anterior end bluntly angled above; posterior dorsal margin shorter, more rapidly descending; posterior margin with a flattened curve; basal margin meeting the posterior in a blunt angle, but curving regularly to meet the anterior; anal depression moderate; sculpture consisting of about 43 ribs, broad on the anterior and middle part of the disc, but narrow on the posterior; interstices narrow, but widening slightly towards the margin; crenulations of the inner margin obsolete posteriorly; ligamental area long and fairly wide, with four well-spaced ligamental grooves; teeth long and strong, horizontal at the extremities of the hinge-line; anterior muscular impression large, triangular; posterior smaller, subquadrate.

Dimensions of holotype (right valve): Height, 74 mm.; length, 75 mm.; thickness, 30 mm.

Localities:—

Target Gully (Park, 1916). (Holotype, in collection of N.Z. Geological Survey.) Specimens collected also by Marshall, Benson, and Finlay.)

649—Paparoa Rapids. (Collected also by Marshall and Murdoch.)

1017—Raekohua Valley, Tangarakau. (Specimen of 108 mm. height.)

Mead Gorge gravels (? from conglomerate). Collected by Dr. Thomson. This specimen was (apparently accidentally) in the Geological Survey locality collection from Awatere Valley, loc. 126, and was accompanied by a label of Suter's, "*Cucullaea alta*." This record must therefore be deleted from *Pal. Bull. No. 8*, p. 30.

? Orari River. (Canterbury Museum collection, fragmentary specimen.)

Point Hill, Glenavy. (Otago University collection.)

? 166—Lower Gorge, Pareora. (A poor specimen, flatter than usual; listed by Suter in *Pal. Bull. No. 8*, p. 57, as *G. subglobosa*.)

483—McKay's "Hutchinson's Quarry greensands," Wharekuri. (A fragment.)

Remarks.—The holotype was used by Suter as a paratype for his *G. subglobosa* from Kakahu. The excellence of its preservation makes one wonder why he did not make it the holotype of his species, instead of the matrix-filled specimen that he used. Perhaps he doubted the exact specific identity of the Target Gully and the Kakahu shells.

Although a large shell, the holotype is not quite full-grown, and so does not present all the characteristics of the old individuals, which are as much as 108 mm. in height. These are thicker and heavier, the shoulders are more rounded, while the area is broad and has encroached on the teeth, which are thick and irregular. The flattened posterior margin is extended ventrally, making the shell more inequilateral.

This species is larger and more tumid than *G. subglobosa*; the ribs, too, are wider. Young shells of *G. robusta* would be very like mature *G. subglobosa*, but the old shells present quite a different appearance, having more rounded shoulders and an inequilateral outline.

Very young shells of, say, 20 mm. height are difficult to separate from the young of *G. huttoni*. The teeth of *G. robusta*, however, are slightly thinner and more horizontal, the hinge-line is narrower, and the anal sinus somewhat shallower. The full-grown shell is more inflated than *G. huttoni*, the hinge-line is longer, the anal sinus much weaker, and the teeth are longer and more nearly horizontal. The flattening of the posterior margin and its extension downwards give the shell a suggestion of a shortened *Cucullaea*, an effect strengthened by the horizontality of the outer teeth. Add to this the fact that the type of *Cucullaea ponderosa* was lost, and we have a fine little pitfall for the palaeontologist. Fortunately, the missing shell has been found, so the error can be corrected. The specimen used by Suter (1914, p. 36) for his description of *C. ponderosa* (and now in the Dominion Museum) is a *Glycymeris robusta*. It measures 102 mm. high, 94 mm. long, and 80 mm. thick (both valves). The measurements and locality given by Suter are taken from Hutton's description, and it will be seen that, while the height of both is 102 mm., the length of the *Cucullaea* is 109 mm., which can hardly be said to "answer very well" to that of the 94 mm. length of the *Glycymeris*. The locality of the shell is unknown, but it may be Hutton's *G. globosa* from Hicks Bay (1873, p. 28).

In an unpublished "List of Tertiary Mollusca in the Canterbury Museum" Hutton gives a photograph of a shell from Porter River which he identified as *Cucullaea ponderosa*. It is almost certainly a *Glycymeris robusta*.

Glycymeris cordata (Hutton). (Plate 2, figs. 1, 6.)

1873. *Pectunculus* (?) *cordatus* Hutton, *Cat. Tert. Moll.*, p. 28.
1886. *Pectunculus cordatus* Hector, *Outline of N.Z. Geology*, p. 51, fig. 6.

Shell comparatively small, heavy, much inflated, roundly trigonal; beaks very broad and high; anterior end broadly curved, sloping steeply from the umbo; posterior end attenuated below; anal depression moderate; sculpture about 35 obscure ribs with linear interstices; ligamental area short and wide, with faint, spaced striae; teeth strong, steeply inclined, not greatly invaded by the area, 8 on each side.

Height (right valve), 34 mm.; length, 31 mm.; thickness, 15 mm.

Lectotype in collection of N.Z. Geological Survey.

Locality.—Wairoa River, Nelson, in large numbers in a brown sand at the mouth of the Wairoa Gorge.

This species is easily identified by its somewhat small size, and the very large, broad beak.

Records to be eliminated from *N.Z. Geol. Surv. Pal. Bull. No. 8*:—

Page 59. White Rock River, loc. 165 = *G. globosa* (worn).

Page 69. Left bank, Waitaki River = *G. waitakiensis* n. sp.

None of the other specimens recorded by Suter could be found, so that no example of *G. cordata* was seen from other than the type-locality.

Glycymeris hurupiensis n. sp. (Plate 2, figs. 4, 5.)

Shell large, heavy, inflated, subquadrate when young but becoming obliquely subrhomboidal at maturity; beaks very prominent, anterior dorsal margin long, sloping gradually to the somewhat narrowly-convex anterior margin; posterior dorsal margin shorter, posterior margin broadly

convex; anal depression moderate; sculpture about 30 broad, flat radials with linear interstices generally obscured towards the edge of the adult by strong, waved growth-lines; inner margin coarsely crenate; ligamental area long and wide, with about 6 lightly-incised ligamental lines; teeth of variable strength, 10–12 on each side.

Height of holotype (right valve), 58 mm.; length, 63 mm.; thickness, 25 mm.

Localities:—

1037—Sandstone, Hurupi Creek, Palliser Bay.

1039—Basal grits, Whakapirihika, east shore, Palliser Bay.

Holotype in collection of N.Z. Geological Survey.

This species may be distinguished from *G. huttoni* by its fewer and broader ribs, by its less-pronounced anal depression, and the ovate shape of the adult shell.

Glycymeris kaawaensis n. sp. (Plate 2, figs. 2, 3.)

Shell large, heavy, inflated, rounded, trigonal almost equilateral; beaks very prominent, anterior dorsal margin sloping fairly steeply to the convex anterior end; posterior dorsal margin short, posterior end broadly convex; anal depression very weak; sculpture 30–35 broad, flat ribs with linear interstices, crossed by strong waved growth-lines towards the margin; ligamental area moderately long and very wide, with 6 somewhat shallow ligamental grooves; teeth short and stout, posterior ones curved; the holotype has 17 in front and 13 behind, 5 at each end free of the area (this, however, seems an exceptionally large number, as paratypes have as few as 3 whole teeth at each end and 2 or 3 rudimentary ones truncated by the area).

Height of holotype (right valve), 61 mm.; length, 65 mm.; thickness, 27 mm.

Locality.—996—Kaawa Creek.

Holotype in collection of N.Z. Geological Survey.

Remarks.—This species can be distinguished from *G. huttoni* and *G. hurupiensis* by its much more sloping shoulders, and the short, curved posterior teeth; from the former also by its anal depression being practically absent, and from the latter by its slightly narrower ribs.

This is the shell identified by Suter as *G. globosa* (Hutton): J. A. Bartrum (1919, p. 104).

Although most of the large shells are thick and heavy, giving a strong resemblance to *G. huttoni*, this does not show the true nature of the species, which is much closer to *G. manaiaensis*. This is shown not only by the shape of the growth-lines of youthful stages, but also by some large individuals which have not become thickened. One specimen, collected by Mr. Bartrum, has a low beak and is very like a large *G. manaiaensis*. The area, however, is short and broad, as in other Kaawa shells. Viewed externally, the beak is seen to be somewhat narrower, the shoulders are more sloping, and the ribs fewer in number.

Glycymeris manaiaensis n. sp. (Plate 3, fig. 4; Plate 4, fig. 4.)

Shell large, of moderate weight, obliquely ovate, inequilateral, moderately inflated; beaks small, not projecting much above the dorsal margin, anterior end practically a semicircle, posterior end somewhat attenuated ventrally; anal depression absent; sculpture 30–35 flat radials with linear

interstices, becoming obsolete towards the margin, where there are numerous waved growth-lines; ligamental area short and narrow, almost smooth, with three scarcely discernible ligamental grooves; teeth about 10 on each side, fairly short and stout, bent in the middle, where there is on each side a short striated facet with raised edges.

Height of holotype (complete individual), 49 mm.; length, 53 mm.; thickness of one valve, 16 mm.

Holotype in collection of N.Z. Geological Survey.

Remarks.—This species may be distinguished from the three preceding ones by its ovate shape, very much lower beaks, moderate inflation, and small, almost smooth, area.

Localities :—

875—Manaia beach. (Holotype.)
Whakino, Hawera (Marshall and Murdoch).
1018—Cliff half a mile north-west of mouth of Patea River.
? 720—"Upper band of Petane limestone." (Fragmentary specimen.)
? 736—"Petane and Scinde Island." (Fragmentary specimen.)
Lower end of Starborough Creek, Awatere Valley (Thomson).
218—Motunau. (Poor specimen.)
219—Motunau. (Poor specimen.)
126—Awatere Valley.
Motunau beds, Middle Waipara (Thomson).
Motunau beds, Lower Waipara (Thomson).
Motunau beds, Weka Pass (Thomson). (Fragment.)
? 41 (red)—Moonlight Creek, Waiwhero Survey District, Westland.

The shells from Whakino, Hawera, are somewhat stronger in the beak than the type, and in some cases have more sloping shoulders. In this respect they approach the variety of *G. kaawaensis* mentioned above. The general affinities are, however, with the Manaia shell.

Although the shells are not at all alike, this species has generally been identified as *G. laticostata*. This seems to have been brought about by an identification made by Zittel. The figure he published is that of an equilateral shell with flat ribs and wide shoulders. It is neither *G. laticostata* nor *manaiaensis*, but apparently belongs to *Glycymeris* sp. [see below, p. 74 (*d*)].

Glycymeris rapanuiensis n. sp. (Plate 3, fig. 1; Plate 4, fig. 1.)

Shell fairly large, not heavily built, disc longitudinally oval, inequilateral; beaks fairly prominent; anterior dorsal margin almost horizontal, anterior end broadly convex; posterior end slightly sinuated above by the anal depression, which is bounded ventrally by a low ridge running from the umbo and making a blunt angle in the posterior margin; sculpture, about 26 very broad flat ribs with linear interstices obscured toward the margin by waved growth-lines; ligamental area small, with 4 lightly incised ligamental grooves; teeth short, curved, with short striated facets at the angle.

Height of holotype (right valve), 45 mm.; length, 52·5 mm.; thickness, 16 mm.

Holotype in collection of N.Z. Geological Survey.

Locality.—895—Mouth of Rapanui River. (Collected also by Mr. L. Grange.)

Remarks.—This species is nearly related to *G. manaiaensis*, as shown by the similar ligamental area and teeth; the beaks of the former, however, are noticeably more prominent, the outline is more oval, and the ribs fewer and wider. This latter characteristic is very marked in the crenulations of the inner margin, which in *G. manaiaensis* are only about half the width of those in *G. rapanuiensis*. The outline and hinge-area distinguish it from the other species of the genus.

Suter classed this shell, as well as the Manaia one, as *G. laticostata*.

Species not good enough for Description.

There are several almost equilateral forms belonging to the *huttoni* group, but to none of the named species. The specimens are poorly preserved and few in number, so their separation and description have not been attempted. Three species, or subspecies, appear to be represented:—

(1.) A shell of moderate size and considerable inflation, with low beaks and about 30 ribs (see Plate 7, fig. 3):—

- (*a.*) Loc. 70—Akuaku, Poverty Bay district (figured).
- (*b.*) Between Blairich and Black Birch Creek, Awatere Valley (Thomson).
- (*c.*) Loc. 154 (?)—Callaghan's Creek, Goldsborough.
- (*d.*) The shell figured by Zittel as *P. laticostatas* (1864, pl. xv, fig. 13*a*, 13*b*) from Awatere Valley.
- (*e.*) Loc. 862—Near head of Waimata River, *N.Z. Geo. Surv. Pal. Bull. No. 8*, p. 10, listed as *G. subglobosa*. There is only a fragment of the beak and hinge, but it is not *subglobosa*.

(2.) A very large shell with wide flat shoulders and narrow beaks:—

- (*a.*) Loc. 649—Paparoa Rapids (also Marshall).
- (*b.*) Loc. 246—Cape Rodney, Auckland.

(3.) A large inflated shell with low rounded beaks and an almost smooth surface:—

Loc. 866—Maungatokerau, Uawa, Gisborne District.

The hinge-line is not clearly shown, so the shell may not belong to this group. It is listed as *G. subglobosa* in *N.Z. Geol. Surv. Pal. Bull. No. 8*, p. 7.

III. The *Axinea* Group.

Glycymeris trelissickensis n. sp. (Plate 5, fig. 4; Plate 6, fig. 4.)

Shell of moderate size, very inflated, almost globular; beaks low, with a very wide angle; outline equilateral, roundly trigonal in youth, longitudinally oval in the adult; anal depression obsolete; sculpture, surface appearing almost smooth, but there are fine close radial riblets over the greater part of the disc, crossed by growth-lines; underneath these, and shown on weathering, is a system of narrow radial ribs; inner margin finely crenate, ligamental area small, closely striated by 4 or 5 grooves (a paratype of advanced age shows a wide area with 12 grooves); teeth small, numerous, about 6 on each side free of the area; muscular impressions subequal.

Height of holotype (right valve), 42 mm.; length, 45·5 mm.; thickness, 16 mm.

Holotype in collection of N.Z. Geological Survey.

Localities :—

239—" Fan coral bed, Porter and Thomas Rivers, Trelissick Basin " (McKay, 1879). (Holotype.)

237—" Upper part Mount Brown limestone," Trelissick.

238—" Mount Brown limestone, Coleridge Creek," Trelissick.

449—" Lower beds, Trelissick Basin " (Enys, 1880).

The matrix and preservation of this shell are similar to that of the holotype, so it is probably from the same horizon, and not from lower beds as stated in McKay's manuscript.

The species is distinguishable from the others of the group by its wider beaks and greater inflation towards the margins.

Glycymeris waipipiensis n. sp. (Plate 5, fig. 5 ; Plate 6, fig. 5.)

Shell very large, regularly inflated, beaks wide and prominent, outline almost circular, anterior regularly rounded, posterior slightly straightened above ; sculpture consisting of very fine radial riblets upon a system of obsolete narrow ribs, about 60 in number ; waved growth-lines are prominent towards the margin ; inner margin very finely crenate ; ligamental area moderate, closely grooved ; teeth small, 7 on each side free of the area ; anterior muscular impression only slightly larger than the posterior.

Height of holotype (complete individual), 77 mm. ; length, 79 mm. ; thickness of one valve, 27 mm.

Holotype in the collection of Dr. Marshall.

Localities :—

Waipipi (Marshall). (Also collected by Murdoch.)

996 Kaawa Creek (small specimens). (Also collected by Bartrum.)

This species is much larger than any of the others in the *Axinea* group, described in this paper. It is intermediate in character between *G. trelissickensis* and *G. shrimptoni*. Small specimens would be distinguishable from the former by their more prominent and narrower beaks, and from the latter by their slightly stronger beaks and higher shoulders.

Glycymeris shrimptoni n. sp. (Plate 5, fig. 3 ; Plate 6, fig. 3.)

Shell of moderate size, inflated, beaks low ; outline almost circular ; anal depression obsolete ; sculpture—the whole disc is covered with fine closely-placed radial riblets, about 6 per millimetre, superimposed upon narrow obsolete ribs each bearing about 10 of the lines at the margin, near which especially there are concentric growth-lines ; inner margin finely crenate ; ligamental area moderate, closely striated by 8 grooves ; teeth small, 7 on each side free of the area ; muscular impressions subequal.

Height of holotype (left valve), 44 mm. ; length, 43 mm. ; thickness, 15 mm.

Holotype in collection of N.Z. Geological Survey.

Localities :—

191—Shrimpton's, Ngaruroro River, Hawke's Bay. (Holotype.)

? 231—McLean's, Ngaruroro River. (Very much worn.)

This species is closely related to *G. trelissickensis*, but the beak is a shade higher and has a narrower angle ; there is also less inflation towards the margins.

Some specimens develop a certain amount of obliquity, but they can always be separated from such species as *G. callaghani* and *G. waitakiensis* by their wider shoulders.

In *N.Z. Geol. Surv. Pal. Bull. No. 8*, p. 19, this species is listed as *G. striatularis* (see below, p. 77).

Glycymeris waitakiensis n. sp. (Plate 5. fig. 2; Plate 6, fig. 2.)

Shell of moderate size, fairly solid, roundly trigonal almost equilateral, inflated; beaks broad, prominent, but only moderately projecting above the hinge-margin; anterior end steeply sloping above, broadly rounded below; posterior end similar, slightly attenuated ventrally; sculpture—the surface is almost smooth but weathering shows very narrow radials corresponding to the fine crenulations of the inner margin; ligamental area short and broad, closely striated by 7–8 grooves; teeth small and fine, about 12 on each side, 6 of which are free of the area.

Height of holotype (left valve), 39 mm.; length, 40·5 mm.; thickness, 15 mm.

Holotype in collection of N.Z. Geological Survey.

Locality.—483—Hutchinson's Quarry greensand, Wharekuri (McKay).

Material, one specimen, in very good preservation.

Remarks.—This shell may be distinguished from *G. trelissickensis* by its trigonal shape, and from *G. callaghani* by its approach to an equilateral disposition.

Listed by Suter in *N.Z. Geol. Surv. Pal. Bull. No. 8*, p. 69, as *G. cordata* (?), in Mr. Uttley's collection.

Glycymeris callaghani n. sp. (Plate 5, fig. 1; Plate 6, fig. 1.)

Shell large, solid, inequilateral, obliquely ovate, inflated; beaks moderate, narrow; anterior end semicircular; posterior end attenuated ventrally; sculpture—surface covered with very fine radial riblets, underlain by obsolete primary ribbing, showing plainly on weathering, these ribs are about 50 in number; inner margin with crenulations of moderate size; ligamental area short but wide, closely striated by 8–10 well-incised grooves; teeth fairly strong; muscular impressions subequal, the posterior with a very strong ridge in front of it.

Holotype in collection of N.Z. Geological Survey.

Height of holotype (right valve), 50 mm.; length, 51 mm.; thickness, 18 mm.

Localities:—

154 (in part)—Greensand, Callaghan's Creek, Kanieri district (*N.Z. Geol. Surv. Rep. No. 9*, 1877, p. 84). (Holotype.) (Collected also by Mr. Bartrum.)

649—Paparoa Rapids, Wanganui River, (The beaks of these specimens are broader than those of the type.)

? 899—Taumatamaire, Awakino. (A small specimen filled with matrix.)

This species may be distinguished from others of the group by its obliquity. The outline is like that of *G. manaiaensis* of the *globosa* group, but the fine ornamentation and closely grooved area easily distinguish it.

Dr. Henderson kindly procured some Callaghan's Creek specimens from the Reefton School of Mines. These show the interior clearly. The ridge in front of the posterior muscular impression is stronger than in any other species of the genus.

Glycymeris modesta (Angas). (Plate 5, fig. 6; Plate 6, fig. 6.)

1879. *Axinea modesta* Angas, *Proc. Zool. Soc.*, p. 418, pl. 35, fig. 4.
1873. *Pectunculus striatularis* Lam.: Hutton, *Cat. Ter. Moll.*, p. 28 (not of Lamarck).
1908. *Glycymeris velutina* Suter, *Trans. N.Z. Inst.*, vol. 40, p. 354, pl. 30, figs. 1, 2.
1913. *Glycymeris modesta* (Angas): Suter, *Man. N.Z. Moll.*, p. 852.

For further synonymy and description see Suter's *Manual.* It must be remembered that Suter mistook the anterior for the posterior of the shell, so his description of the beaks should read "slightly curved backwards," and so on.

Localities:—

Holotype, Recent.
207, 208, 768—Shakespeare Cliff, &c., Wanganui.
720—Upper band, Petane limestone.
191—Shrimpton's, Ngaruroro River, Hawke's Bay.
996—Kaawa Creek, Auckland. (Small specimens.) (Also collected by Bartrum.)

The lowest horizon in the Wanganui district recorded for this shell by Marshall and Murdoch is Nukumaru.

Beyond the characters of the "group," this shell shows no close affinities with any other New Zealand shell, and, as the original stock apparently became established in this area about the commencement of the Wanganuian, it would be interesting to know from whence it came. Suter mentions its occurrence at the Kermadec Islands; but it is omitted by Oliver (1915, p. 567) in his list of mollusca from that locality.

Species to be eliminated from New Zealand Lists.

Glycymeris convexa (Tate).

1885. *Pectunculus convexus* Tate, *Trans. Roy. Soc. S. Aust.*, vol. 8, p. 138, pl. xi, fig. 7 *a, b.*
1921. *Glycymeris convexa* (Tate): Suter, *N.Z. Geol. Surv. Pal. Bull. No. 8*, p. 49.

The occurrence of this species in New Zealand strata is based on a single record (Suter, 1921, p. 49) from locality 449, Trelissick Basin. Strange to say, of the three shells in this collection, this particular specimen is missing, so that no definite statement can now be made as to its identity, and until this specimen is found, or further material collected, the Australian species cannot safely be said to occur in New Zealand.

Glycymeris striatularis (Lamarck).

1835. *Pectunculus striatularis* Lamk., *An. s. Vert.*, vol. 6, p. 493.

This is a Recent shell from King George Sound, Western Australia. It has been recorded doubtfully by E. A. Smith (1885, p. 252) from Port Jackson, but Hedley (1918) says the identification is erroneous.

Hutton (1873, p. 28) and others used the name for the Wanganui and Recent shells now classed as *G. modesta.* Suter, while recognizing *modesta* for these shells, has used *striatularis* in three other cases: (*a*) For specimens from Kaawa Creek (Bartrum, 1919, p. 104) belonging to the *Axinea* group, and very likely a young *G. waipipiensis*; (*b*) for small specimens

of *G. modesta* from Kaawa Creek; (*c*) for specimens from 191– Shrimpton's (Suter, 1921, p. 19).

This shell is also an *Axinea*, and is here classed as a new species, *G. shrimptoni.*

Note on *Glycymeris concava* Marshall var. (Plate 7, figs. 1. 4.)

Glycymeris concava Marshall, *Trans. N.Z. Inst.*, vol. 49, p. 459, pl. 36, fig. 42, 1917.)

As the Wangaloa beds from which this shell comes are probably Upper Cretaceous, this species has not been included with the Tertiary ones described above.

Dr. Marshall kindly sent some of the type-material of the species, including the holotype.

The paratype, 65 mm. high, 63 mm. long, here figured, is worthy of notice on account of its very strong beaks. It seems to be entitled to at l ast subspecific rank, a matter which can be cleared up when the Wangaloan fauna is being revised.

Summary of Specific Characters.

(These must be considered as only approximate.)

I. *Laticostata* group: Equilateral; circular or dorso-ventrally oval; low beaks; area steep, closely grooved.
- (*a.*) *lornensis*: Small, subtriangular, ribs broad, beaks moderate.
- (*b.*) *traversi*: Ribs and interstices of equal width all over the disc.
- (*c.*) *laticostata*: Interstices narrower and ribs broader on anterior half.
- (*d.*) *chambersi*: Ligamental area very densely striated, ribbing fairly regular.

II. *Huttoni* group: Flat obsolete ribs, linear interstices, beaks generally strong, ligamental grooves widely spaced.
- (*a.*) *subglobosa*: Equilateral, 55 ribs, beaks wide, shoulders high.
- (*b.*) *huttoni*: Subquadrate, strong anal depression, 45 ribs, beaks high.
- (*c.*) *robusta*: Subquadrate, shoulders rounded, 43 ribs, interstices widening towards the margin.
- (*d.*) *cordata*: Beaks very high and broad, shell small.
- (*e.*) *hurupiensis*: Obliquely rhomboidal, 30 ribs, beaks strong, shoulders rounded and sloping.
- (*f.*) *kaawaensis*: Broadly trigonal, 35 ribs, beaks strong, shoulders sloping.
- (*g.*) *rapanuiensis*: Longitudinally oval, ligamental area small and smooth, beaks moderate, 30 ribs.
- (*h.*) *manaiaensis*: Ovate, ligamental area small and smooth, beaks low, 35 ribs.

III. *Axinea* group: Circular to trigonal, smooth or with very fine surface radials, the primary ribs underneath are narrow, inner margin finely crenate, ligamental area steep, very closely grooved.
- (*a.*) *trelissickensis*: Globular, beaks low but very wide.
- (*b.*) *waitakiensis*: Subtrigonal, beaks strong.
- (*c.*) *callaghani*: Obliquely ovate, beaks narrow and prominent.
- (*d.*) *waipipiensis*: Very large, circular, beaks prominent.
- (*e.*) *shrimptoni*: Moderate size, circular to slightly oblique, beaks narrow and fairly prominent.
- (*f.*) *modesta*: Very small, trigonal, beaks noticeably curved backwards.

—	Upper Senonian.	Wangaloa.	Lower Waiarekan.	Upper Waiarekan.	Ototaran.	Hutchinsonian.	Awamoan.	Wanganuian.	Recent.
Laticostata group	..	..	..	..	..	..	*traversi.*		
	..	..	..	..	..	..	*chambersi.*		
	..	..	..	*lornensis*	..	..	*laticoststa* (?)	*laticostata* ..	*laticostata.*
	..	*concava.*							
	selwynensis.								
Globosa group	..	..	*subglobosa*	..	..	*huttoni* (?)	*huttoni.*		
	..	..	..	..	..	..	*robusta.*		
	..	..	..	..	..	..	*hurupiensis*	*kaawaensis.*	
	..	..	..	..	..	..	*cordata* (?)	*rapanuiensis.*	
						..	..	*manaiaensis.*	
Axinea group	..	..	..	..	*trelissickensis* (?)	*trelissickensis* (?)	..	*waipipiensis.*	
	..	..	..	..	..	..	..	*shrimptoni.*	
	..	..	..	..	..	*waitakiensis* (?)	*callaghani* (?)		
	..	..	..	..	..	..	..	*modesta* ..	*modesta.*

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ART. 3.—*On the Discovery of the* Liothyrella boehmi *Greensand Band at Flume Creek, Waitaki Valley.*

By Professor JAMES PARK, F.G.S., F.N.Z.Inst., Dean of the Faculty of Mining at Otago University.

[*Read before the Otago Institute, 8th November, 1921; received by Editor, 12th November, 1921; issued separately, 1st February, 1923.*]

AT the lower end of Flume Gully, about a mile from Papakaio, the yellow-and-black speckled mineral tuffs which occupy the floor and lower sides of the valley are overlain conformably by a bed of compact yellowish-brown calcareous sandstone about 40 ft. thick. The lower part of this sandstone is highly glauconitic, and the upper part is intercalated with bands and lenses of hard impure limestone.

At the junction of the tuffs and overlying glauconitic layer there is an irregular streak of gritty, pebbly conglomerate, ranging from almost nothing to about 2 in. thick. The material in this grit-band is mainly flinty quartz and black minerals. In size it ranges from sand-grains to well-rounded pebbles 1½ in. in diameter.

The dip of the tuffs and associated calcareous sandstone is towards the north at a low angle. The course of Flume Gully is almost at right angles to the strike, which coincides approximately with the trend of the Waitaki Valley.

On the west side of the gully, at a point about 100 yards above the big flume and 55 ft. above the floor of the valley, I discovered in the soft glauconitic band overlying the tuffs and in the pebbly band a rich marine fauna, containing prominently, among many other shells, a profusion of well-preserved examples of the large and beautiful *Liothyrella boehmi* (Thomson).

The molluscs collected here included—

Epitonium lyratum (Zitt.)	*Pecten hochstetteri* Zitt.
Siphonalia conoidea (Zitt.)	*Pecten delicatulus* Hutt.
Turbo marshalli Thomson	*Pecten huttoni* (Park)
Crepidula costata (Sow.)	*Ostrea wuellerstorfi* Zitt.

From the same bed I collected the brachiopods—

Liothyrella boehmi (Thomson)	*Pachymagas ellipticus* Thomson
Liothyrella oamarutica Boehm	*Neothyris tapirina* (Hutt.)
Terebratulina suessi Hutt.	*Rhizothyris rhizoida* (Hutt.)
Aetheia gualteri (Morris)	*Hemithyris* sp. cf. *squamosa* (Hutt.)

Of these, *Liothyrella boehmi*, *Aetheia gualteri*, and the species of *Hemithyris* are the most common.

Associated with the molluscs and brachiopods occur many Polyzoa, represented typically by a large cup-shaped *Celepora*, several corals, including *Isis dactyla* T.-Woods (some of the joints of which were found over 1 in. in diameter and 2½ in. long), *Cidaris* spines, *Graphularia* sp., and cetacean-bones, the latter fairly abundant. Some 30 yards nearer the flume, in the uppermost layer of the tuffs, I found a good example of *Liothyrella boehmi* and one example of *Aetheia gualteri*.

My success at Flume Gully led me to an examination of the lower glauconitic horizon further afield. I discovered almost the same assemblage of brachiopods in the glauconitic band underlying the Maruwhenua limestone at the old gold-workings; also in the same band below the Ngapara stone at Weka Creek, Ngapara, at Pukekarara Creek, a mile and a half due east of Tokarahi Railway-station.

The brachiopods seem to occur only where the band is moderately glauconitic. Where it is intensely glauconitic there is usually an absence of both molluscs and brachiopods.

The assemblage of brachiopods found at Flume Gully is practically the same as that occurring in bed *c*, fig. 25, overlying the Oamaru stone in Landon Creek;* in the calcareous glauconitic tuffs overlying the Oamaru stone near Sebastopol;† in the calcareous glauconitic tuffs overlying the Oamaru stone east of Rocky Peak;‡ and in the calcareous tuffs underlying the Kakanui (= Deborah) limestone and overlying the Oamaru stone at Kakanui and neighbourhood.§

But this brachiopod assemblage also occurs in the glauconitic sandstone band underlying, or forming, the lowermost part of the Waitaki stone near Duntroon,‖ Maruwhenua, and Ngapara. And from these facts I conclude (*a*) that the Waitaki stone overlies the Oamaru stone: (*b*) that the Kakanui, Flat Top Hill, and Deborah limestones, as well as the upper bands of limestone or calcareous glauconitic sandstone at Sebastopol, Landon Creek, and Flume Gully, are the equivalent of the Waitaki stone; and (*c*) that the *Liothyrella boehmi* brachiopod horizon below the Kakanui limestone is the equivalent of the glauconitic sandstone band immediately below the Waitaki stone.

The new evidence strengthens my contention (*a*) that in the Oamaru area there are two limestone horizons—viz., the Oamaru limestone and

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* J. PARK, The Geology of the Oamaru District, *N.Z. Geol. Surv. Bull. No. 20* (*n.s.*), p. 63, 1918.

† J. PARK, *l.c.*, p. 74.

‡ J. PARK, *l.c.*, p. 72.

§ J. PARK, *l.c.*, pp. 58, 69, 71.

‖ J. PARK, *l.c.*, p. 83. See also G. H. Uttley, *Trans. N.Z. Inst.*, vol. 50, p. 124, 1918.

the Kakanui limestone (or Waitaki stone); and (*b*) that in the Maruwhenua-Ngapara area the Oamaru limestone is represented by clayey and sandy beds underlying the *Liothyrella boehmi* zone.

At Kakanui the Kakanui limestone is separated from the Oamaru stone by a great thickness of mineral tuffs, and the outcrops of the two limestones lie far apart. To the west the tuffs diminish rapidly in thickness, and eventually disappear near Weston and Totara. As a consequence of this the limestone outcrops converge to the westward, and at Sebastopol and in the area lying to the west of that hill the two rocks rest on one another, forming one escarpment; but the glauconitic band is always present between them, though not everywhere fossiliferous.

Towards the Waitaki area the Oamaru stone thins out and then disappears, but the glauconitic *Liothyrella boehmi* band and the overlying Waitaki stone are still present.

It is noteworthy that the discovery of this useful reference-horizon was due to the assiduous and careful collecting of Mr. Uttley, supplemented by the painstaking identification of species by Dr. Thomson.

The only modification introduced into my grouping (1918) of the Oamaruian by the discovery of the *Liothyrella boehmi* zone, omitting the conglomerate band, which is often absent, is the correlating of the Kakanui limestone with the Waitaki stone. Thus we get—

Awamoan .. Clays and shelly sands.

Hutchinsonian—

(*a*) Upper—Limestone (Waitaki, Kakanui) (*Pachymagas parki* horizon).

(*b*) Lower—Glauconitic sandstone band (*Liothyrella boehmi* horizon).

Ototaran—

(*a*) .. Mineral tuffs } To west and north, clayey and sandy beds.
(*b*) .. Oamaru stone }

Waiarekan .. Volcanic tuffs. To west and north, clayey and sandy beds.

Ngaparan .. Quartz sands, grits, and conglomerates, with lignite.

Art. 4.—*On the Relation of the Oamaru Limestone and Waitaki Stone.*

By Professor James Park, F.G.S., F.N.Z.Inst., Dean of the Faculty of Mining at Otago University.

[*Read before the Otago Institute, 8th November, 1921; received by Editor, 12th November, 1921; issued separately, 1st February, 1923.*]

The principal theme of a paper by Mr. G. H. Uttley, M.A., M.Sc., F.G.S., published in the *Transactions of the New Zealand Institute** is what he calls the "two-limestone theory of Professor Park." Mr. Uttley's contention is that the Waitaki stone is the horizontal equivalent of the Oamaru limestone. In the beginning I may say that I am tempted to deny the gentle charge that the invention of what he calls the "two-limestone theory" is mine. Perhaps my disclaimer is unnecessary, since Mr. Uttley† himself supplies the correction when he tells us "that McKay's 'two-limestone theory' [1877 and 1882] is radically different from Park's 'two-limestone theory'" [1905 and 1918].

Mr. Uttley rightly quotes me as having written,‡ in 1887, "Standing on the high hills surrounding Ngapara, it is quite obvious that the Ototara

* *Trans. N.Z. Inst.*, vol. 52, pp. 169–82, 1920.
† G. H. Uttley, *loc. cit.*, p. 139.
‡ J. Park. *Rep. Geol. Explor. during 1886–87*, p. 140, 1887.

stone at one time formed a continuous bed." I now know how fallacious an observation made from a distant hilltop may be. Clearly, the obvious, as cogently argued by Carlyle, may easily conceal the truth.

In the summer of 1916–17 the mapping of the area lying to the west of the railway-line for the first time disclosed the error I had fallen into in 1886 in concluding from a bird's-eye view of the country that the Oamaru and Ngapara limestones were part and parcel of the same sheet.

In 1920 I spent two weeks, and in the present year four weeks, in the coastal and western parts of the Oamaru and South Canterbury districts, concerning myself mainly with the position of the *Liothyrella boehmi* horizon and the relationship of the Oamaru and Waitaki stones. I again traced the Waitaki stone to Ngapara and Tokarahi, and examined the country between Enfield, Windsor, Big Hill, and Ngapara. I satisfied myself that I was right (1904, 1910, and 1918) in regarding the Waitaki, Maruwhenua, Ngapara, and Tokarahi stones as part and parcel of the same sheet; and, of no less importance, confirmed my survey of 1918, which showed that the Oamaru stone does not connect with, or come within many miles of, the Ngapara limestone.

Among other places I revisited this year was the high ground overlooking Windsor Junction. From this elevation the Oamaru-stone escarpment behind Cormack's is seen to approach Enfield, whence with its cover of Kakanui limestone it sweeps northward to Teaneraki Cliffs and beyond this to Table-top Hill. The escarpment now trends north-west in the direction of Big Hill, giving the impression as viewed in perspective that the Oamaru stone forms the cap of Big Hill itself and of the scarp-bounded mesas lying between Big Hill and Ngapara.

As shown by my mapping (1918), the Oamaruian strata are arranged in a flat anticline, the axis of which runs north-eastward from Elderslie to the west of Big Hill. In consequence of the slight tilt of the strata, first the Waiareka tuffs, and then the quartz-conglomerates of the Upper Ngaparan, emerge to the north of Table-top Hill from below the Oamaru stone. The Waiareka tuffs form the escarpment as far as the head of Horse Gully, while to the north and west the quartz-conglomerates occupy the summit of Big Hill, where the dip is still to the south-east. The isolated mesas around Ngapara are also capped by conglomerates, which are horizontal or dip gently to the north-west.

Along the eastern or coastal fringe of the anticline the strata are bent into minor synclinal and anticlinal folds. The best developed of these is the Awamoan syncline, a N.W.–S.E. fold which closes to the north-west, where it gradually merges into the eastern limb of the major anticline.

I have recently examined many of the fine natural sections in the Waihao area, and find myself in agreement with Mr. McKay and Dr. Thomson that the Mount Harris or Elephant Hill beds rest conformably on the Waihao stone. On palaeontological grounds these observers have assigned the Mount Harris beds to the Awamoan. With this view both Mr. Uttley and I agree. But the contention of Dr. Thomson and Mr. Uttley that the Waihao stone is the horizontal equivalent of the Oamaru stone implies the absence of the whole of the Hutchinsonian in South Canterbury. As urged by me in 1918,* such a hiatus would mean an unconformity between the Waihao stone and the Mount Harris beds. Of this, however, there is no evidence. Clearly, if the Mount Harris beds are Awamoan, the Waihao stone must be Hutchinsonian.

* J. Park, The Geology of the Oamaru District, *N.Z. Geol. Surv. Bull. No. 20 (n.s.)*, p. 110, 1918.

When dealing with analogous conditions at Otiake Mr. Uttley gets over the difficulty by the simple expedient of combining the Hutchinson and Awamoan beds in what he calls* the "Hutchinsonian-Awamoan horizon." But each of them taken by itself is a series of fossiliferous beds of great thickness. How then, may I ask, can the two when combined form one horizon?

Mr. Uttley attempts to justify his view on physical and palaeontological grounds. He rightly quotes my statement that there is no sharp line of demarcation between the Hutchinsonian and Awamoan. The close stratigraphical relationship of the two series has always been recognized by New Zealand geologists, but surely this cannot be regarded as a valid reason for the creation of a "Hutchinsonian-Awamoan horizon." Following this line of argument, we might as well deny the separation of the Ordovician and Silurian, Triassic and Jurassic, Miocene and Pliocene; or deny the right of historians to divide historic time into periods.

During my survey of the Oamaru district in 1916–17 I discovered a hitherto-unknown fossiliferous horizon in the Upper Hutchinsonian at Target Gully, containing many casts of *Pachymagas parki*, and separated from the overlying Target Gully Awamoan shell-bed by about 20 ft. of soft glauconitic sandstone. From the friable glauconitic sandstone of this horizon (bed *c*, fig. 35, *Geol. Surv. Bull. No. 20*, p. 80) I collected seventy-two species of Mollusca. Mr. H. Suter, who made the identifications, recognized twenty-nine of these as living species, equal to 40·3 per cent. Mr. Uttley† argues that because some 33 per cent. of the three hundred species of Mollusca from the overlying Awamoan beds in the Oamaru district are Recent "there would seem to be no justification for separating these beds from the Awamoan horizon."

I do not think Mr. Uttley's argument is sound; and if we followed it to its logical conclusion we should get curious results. It is well known that station exercises a powerful influence on the distribution of molluscan life. Of the few molluscs recorded from the Oamaru stone none are Recent, while the overlying tufaceous beds contain about forty-five molluscs of which about 31 per cent. are still living. The marly greensands under the Kakahu limestone contain 37 per cent. of Recent species‡; whereas collections from the Pareoran (Awamoan) of South Canterbury contain only 27 per cent. of living forms.§

The grouping and correlation of horizons based on small collections must always be regarded with suspicion. Frequently they give results that are altogether erroneous.

In his latest paper Mr. Uttley‖ seems to have modified or receded from his "Hutchinsonian-Awamoan" hypothesis. He says: "(6.) The occurrence of Awamoan fossils in the beds (Otiake beds) above the limestone of the Waitaki Valley, and the fact that the Awamoan and Hutchinsonian are 'part and parcel of the same series,' as Hutton, McKay, and Park have asserted, further strengthens the argument that this limestone [Otiake] is Ototaran."

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* G. H. Uttley, (1) Tertiary Geology of the Area between Otiake River (Kurow District) and Duntroon, North Otago; (2) Tertiary Geology of the Area between Wharekuri and the Otiake River, North Otago, *Trans. N.Z. Inst.*, vol. 52, pp. 151, 153, 154, 164, 167, 1920.

† *Trans. N.Z. Inst.*, vol. 52, p. 174, 1920.

‡ *N.Z. Geol. Surv. Pal. Bull. No. 8*, p. 54, 1921.

§ *Loc. cit.*, p. 58.

‖ *Trans. N.Z. Inst.*, vol. 52, p. 182, 1920.

Perhaps I may say that the phrase "the same succession" would express my own and McKay's meaning better than the words "the same series" quoted above.

Mr. Uttley immediately continues: "(7.) Nevertheless, the brachiopod fauna of the greensands in the Oamaru coastal district enables a clear line of demarcation to be drawn in that area between the Hutchinsonian and Awamoan." With this I am in complete agreement. But my bed *c* of fig. 35 at Target Gully, previously referred to, contains an abundance of brachiopods (see *Geol. Surv. Bull. No. 20*, p. 81), while the hard brown glauconitic sandstone stratum (bed *d*) which underlies the Awamoan and closes the Hutchinsonian contains casts of *Pachymagas parki* in great abundance. Therefore, according to Mr. Uttley's own view quoted above, bed *c* of fig. 35 cannot be regarded as Awamoan.

I am of the opinion that if the new horizon (bed *c*) at Target Gully were opened up a rich harvest of molluscs would be obtained. Experience has shown that exhaustive collecting in the Cainozoic formations tends to decrease and not increase the proportion of living forms. Apart from further discoveries, the presence of so many brachiopods in beds *c* and *d* proves that Mr. Uttley has failed in his contention that "there would seem to be no justification for separating these beds from the Awamoan horizon."

In 1918 I described a section a quarter of a mile east of Flume Creek* in which a yellowish-brown calcareous slightly glauconitic sandstone intercalated with harder bands contains the coral *Isis* in abundance. This rock conformably overlies a greyish-white limestone that in its upper part is hard and semi-crystalline, and rests on volcanic tuffs and mineral breccias. These tuffs were first described as occurring in this area by Mr. Uttley. An assemblage of brachipods in which *Liothyrella boehmi* Thomson is prominent occurs at the base of the glauconitic sandstone and upper part of the mineral tuffs. If any reliance is to be placed on the zonal value of the brachiopod fauna it is evident that what I have classified as the upper band of Oamaru stone† must be grouped with the Deborah (or Kakanui) limestone lying above it. The importance of this section is second only to that at the mouth of Flume Creek. Mr. Uttley states that he "was unable to find it."

I have examined the section in question twice in the present year and found that the *Isis* band, as I stated in 1918, does underlie the brown glauconitic sandstone with the intercalated hard limestone layers. I now find that the coral I called *Isis* is the related *Mopsea*.

Mr. Uttley in discussing this section continues, "Even if the glauconitic sandstone (bed *g* of fig. 28) does occur as shown in section above . . . no evidence has been presented to show that it is the equivalent of the limestone of the Waitaki Valley near Duntroon." He himself does not hesitate to correlate the so-called Otiake limestone with the Maruwhenua limestone, notwithstanding that the former occurs as an isolated downfaulted block lying between two ridges of Palaeozoic rock, one of which separates it from the Otekaike limestone, the nearest Cainozoic rock, which may or may not be the horizontal equivalent of all or a part of the Maruwhenua stone.

Mr. Uttley maintains that the Waitaki stone near Duntroon is a limestone as pure in many parts as the typical Ototaran (Oamaru) limestone.

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* J. PARK, *N.Z. Geol. Surv. Bull. No. 20 (n.s.)*, p. 65, 1918.
† *Loc. cit.*, p. 66.

But in saying this he has fallen into an error. The Oamaru stone is essentially a polyzoan limestone of high but even grade, the calcium-carbonate content seldom falling below 90 per cent. except where mingled with volcanic ash. Its distribution shows that it is local, and that it accumulated as an off-shore reef or bank where no terrigenous matter was being deposited. On the other hand, the Waitaki stone is a low-grade arenaceous limestone of extremely variable composition.

As a rule, the typical Oamaru building-stone is so soft that it can be cut with a saw as readily as a log of pinewood. I have examined 110 sections of Oamaru stone from Gay's Weston quarry, and forty-two from Totara, Teschemaker's, and Deborah. The Polyzoa range from 28 to 94 per cent., the difference from 100 being made up for the most part by Foraminifera with some echinoderm plates and rarely shell-fragments. The average sample contains about 60 per cent. of Polyzoa and 30 per cent. of Foraminifera. Dr. P. Marshall* has described a sample of Oamaru stone as composed of Polyzoa, echinoderm plates, and Foraminifera in about equal proportions. I am satisfied that the sample examined by Dr. Marshall was not representative.

The Waitaki stone, as typically developed near Duntroon, is an impure arenaceous limestone intercalated with thin layers of higher-grade limestone that weather out in the escarpment-faces as prominent bands. The analysis† quoted by me, and referred to by Mr. Uttley,‡ is that of a sample collected from several of the highly calcareous bands mentioned above. It may be said that these bands taken altogether comprise less than 20 per cent. of the Duntroon stone.

Mr. Uttley§ also refers to the Bortonian stage, the existence of which is based on the occurrence of an assemblage of molluscs of an ancient Cainozoic type at Black Point, near Borton's, in the Waitaki Valley. The first collection at this place was made by Mr. McKay‖ in 1876, who reported, among other forms, the occurrence of *Ancyloceras* and *Scaphites*. No Secondary cephalopods were found by me in 1904 or 1918; but the collections made by McKay (1876) and by me (1918) contained three genera new to the New Zealand fauna, and several gasteropods of an ancient type, fully justifying my old colleague in placing these beds in the so-called Cretaceo-Tertiary system of the First Geological Survey.

The fossils from near Windmill Creek and Papakaio were provisionally referred by me to the Bortonian. The limitations mentioned by Mr. Uttley were clearly recognized by me, hence the separate lists of fossils I gave in 1918.¶ Till Mr. Uttley is able to furnish some new facts about the horizon of the fossils occurring near Windmill Creek and Papakaio we may, I think, let the provisional correlation stand. Dr. Thomson has said that most of the fossils from Black Point occur as casts. That statement can refer only to the forms obtained from the weathered skin of the concretionary masses. The fossils from the middle of the boulders are mostly testiferous and well preserved.

In a note to my paper "On the Age and Relations of the New Zealand Coalfields" I stated that I had obtained evidence in north Otago and south Canterbury confirming my view that the Pareora beds underlie the

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* *Trans. N.Z. Inst.*, vol. 48, p. 92, 1916.
† *N.Z. Geol. Surv. Bull. No. 20 (n.s.)*, p. 115, 1918.
‡ *Trans. N.Z. Inst.*, vol. 52, p. 178, 1920.
§ *Loc. cit.*, pp. 178–79.
‖ *Rep. Geol. Explor. during 1876–77*, p. 52, 1887.
¶ *N.Z. Geol. Surv. Bull. No. 20 (n.s.)*, pp. 34, 35, 1918.

Oamaru stone and therefore belong to the Oamaru series.* I need hardly say that the "Pareora beds" I referred to belonged to the Pareora series of Hutton. It was to eliminate the confusion arising from the application of this name by some observers to beds below, and by others to beds above, the limestone that in 1905 I adopted the name "Awamoa" in preference to "Pareora" when dealing with beds definitely known to overlie the Mount Brown (or Hutchinsonian) beds.†

My classification‡ of 1905, with "*a.* Waitaki stone" deleted, still represents the stratigraphical succession of the Lower Cainozoic formations of New Zealand as we know them to-day. The inclusion of the Waitaki stone was an attempt to reconcile Captain Hutton's views with those of the Geological Survey.

The *Liothyrella boehmi* assemblage of brachiopods previously alluded to underlies the Kakanui (or Deborah, Waitaki, Maruwhenua, Ngapara, Tokarahi) limestone, but overlies the Oamaru building-stone. I can only repeat that if, as claimed by Dr. Thomson and Mr. Uttley, this assemblage possesses zonal value, we must admit that the Waitaki limestone is not the horizontal equivalent of the Oamaru stone, but occupies a higher position in the Cainozoic succession of south Canterbury and north Otago, being separated from the Oamaru stone by the *Liothyrella boehmi* horizon.

The Oamaruian succession in the Oamaru coastal area and in the Waitaki–Ngapara area is shown below :—

Stage.	Coastal Area.	Waitaki–Ngapara Area.
Awamoan ..	Awamoa beds	Awamoa beds.
Hutchinsonian ..	Deborah limestone ..	Waitaki limestone.
	L. boehmi band	*L. boehmi* band.
Ototaran ..	Mineral tuffs	(*a*) Grey sandy beds.
	Oamaru stone	(*b*) Bortonian.
Waiarekan ..	Waiareka tuffs	
Ngaparan ..	Ngapara grits, sands, &c. ..	Ngapara grits, sand, &c.

ART. 5.—*On the Character of the Contact between the Ngaparan Beds and the Underlying Bed-rock.*

By Professor JAMES PARK, F.G.S., F.N.Z.Inst., Dean of the Faculty of Mining at Otago University.

[*Read before the Otago Institute, 8th November, 1921; received by Editor, 12th November, 1921; issued separately, 1st February, 1923.*]

AN examination of the surface of the bed-rock on which the Ngaparan lignitic beds rest should afford much useful information as to the configuration of the ancient land-surface immediately prior to the deposition of the quartz drifts which constitute the lowermost sediments of that series. Unfortunately, in consequence of faulting and the presence of superficial deposits of Recent age along the line of contact, it has been difficult to gather trustworthy data on this interesting subject, and I can only give a few examples that have come under my own observation.

* *Trans. N.Z. Inst.*, vol. 36, p. 418, 1904.
† *Trans. N.Z. Inst.*, vol. 37, p. 492, 1905.
‡ J. PARK, *loc. cit.*, p. 492.

At Cape Rodney, on the east coast of North Auckland, the fossiliferous breccias at the base of the Waitemata series of Oamaruian age rest on the uneven surface of a jagged ridge of Trio-Jurassic argillites and greywacke.

Farther south, at the west end of Motutapu Island* in the Waitemata Harbour, marine erosion has exposed a good section of the basement beds of the same Cainozoic formation abutting against and overlapping the Trio-Jurassic rocks which rise up somewhat abruptly above sea-level, forming a ridge that runs to the eastward. As the lowermost beds of the younger series are not uncovered, it is impossible to say how far they overlap the uneven bed-rock on which they rest; but the character of the material tends to show that no great thickness of strata exists below the breccia exposed on the beach.

At Puketawai, lying six miles east of Te Kuiti, a ridge of Middle Mesozoic rocks rises up through the Oamaruian coal-measures, thereby interrupting the continuity of the coal. Though the actual contact is not seen, boreholes have shown that the sides of the ridge are steep. Other outcrops of the bed-rock occur to the north and west, a circumstance which seems to show that the coal-measures in this area were deposited on a terrain dissected in the early Cainozoic into hollows and ridges. The floor of the same coal-measures at the old Taupiri workings as exposed along the outcrop is not rugged but gently undulating.

On the Mount Arthur tableland, Nelson, the Oamaruian formation is represented by a thin bed of gravelly conglomerate overlain directly by a horizontal sheet of hard limestone. Here the conglomerate rests on a fairly even peneplained surface of Palaeozoic rock.

Near Stony Creek, in the Takaka Valley, the same Cainozoic limestone lies directly on a remarkably even platform of Ordovician crystalline limestone.† To the north of this, in the Aorere Valley, isolated blocks of the Oamaruian limestone are underlain by quartz sands which rest on a peneplained surface of Palaeozoic slaty argillite.

In the upper part of Big Hill Creek, to the west of Big Hill, in the Awamoko Survey District, Oamaru, a sharp pinnacle of phyllite projects into the quartz sands of the Ngaparan lignitic series.‡ In the same area I recently discovered an isolated ridge of russet-brown semi-metamorphic Kakanuian schist projecting into the quartz sands of the lignitic series at a place a mile from Ngapara, close to the sand-pit facing the main road and railway to Oamaru. The outcrop begins at the south-east corner of Section 14A, and passes into Section 15A of Block VII for a distance of 50 yards or more. It rises into the sands to a height of 40 ft. It was noted that the strike of the Palaeozoic rock is N.W.–S.E., and the dip, though this is somewhat obscure, to the south-east at high angles. The slope of the schist-ridge on the side presented towards Ngapara is steep. To the eastward the slope is gentle. The sands wrap around and ride over the ancient ridge, rising above it to a height of 180 ft.

At Port Craig, south of Mussel Beach, on the south-west side of Te Waewae Bay, Southland, the breccias, conglomerates, and limestones at the base of the Oamaruian are seen resting on a deeply eroded and uneven floor of diorite.§

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* J. Park, *Rep. Geol. Explor. during 1886–87, No. 18*, p. 225, 1887.

† J. Park, *Rep. Geol. Explor. during 1888–89, No. 20*, p. 226, 1890.

‡ J. Park, *N.Z. Geol. Surv. Bull. No. 20 (n.s.)*, p. 21, 1918.

§ J. Park, The Geology and Mineral Resources of South-west Southland, *N.Z. Geol. Surv. Bull. No. 23 (n.s.)*, p. 51, 1921.

In 1906 Dr. J. M. Bell called certain uplands in Westland a "fossil peneplain," and in 1916 Professor C. A. Cotton described the even, gentle slopes descending from the uplands to the west towards the middle Kakanui Valley, and forming a conspicuous land-feature from almost all the higher ground around Oamaru, as a "fossil peneplain" or "fossil plain." Dr. J. A. Thomson, F.G.S., has done the same, but I am at the moment unable to put my hand on the reference. Certain mountain areas in Central Otago have also been described by Professor Cotton as "fossil peneplains." The latter has on more than one occasion followed the Davisian nomenclature, which describes an ancient peneplain laid bare by the ordinary processes of denudation as a "stripped peneplain." This, I think, is a misuse of a common English word in a way that probably conceals the real meaning of the users, and, moreover, seems to convey the subtle and erroneous inference that the surface of the peneplain as it now exists is the same surface as that on which the covering sediments were laid down. Of all the processes of denudation there is none capable of uncovering a peneplain at such a rapid rate as to justify the use of the term "stripped peneplain." The uncovering of a peneplain must, from the nature of the agencies involved in the work, be a slow process, conceivably spread over scores of thousands of years. To my mind the term "uncovered peneplain" seems to fit the conditions and circumstances of the uncovering with more accuracy than the term "stripped peneplain."

The use of the term "stripped peneplain," besides implying an action that we know to be untrue, like the term "fossil peneplain," conveys the impression that the uncovered peneplain as we now view it is the actual surface on which the cover of younger strata actually rested.

If the wastage or denudation of the covering strata proceeded at such a rate as to expose the orginal surface of the peneplain everywhere at approximately the same date, and if, after this event had come about, denudation were held in abeyance, then we should behold what was in deed and in fact a true "fossil peneplain."

The first condition is not impossible. If the covering beds consisted of weak unconsolidated sediments of fairly uniform character the rate of degradation might be fairly uniform over a wide area. But there is only one agent that could stay the progress of denudation, and that is a protecting covering of ice. Such an ice-sheet may have existed on the uplands during the Pleistocene, but clearly on the disappearance of the ice denudation would once more begin its activities.

The frequent tors of rock on the Barewood peneplain and high stacks on the table-topped summit of the Rock and Pillar and Old Man ranges are an evidence of the progress of denudation since the Otago peneplain was uncovered. Moreover, they prove that the present surface of the relics of the ancient peneplain in Central Otago is not the original peneplained surface. For that reason I think that the term "fossil peneplain" or "fossil plain," though perhaps not so inaccurate as the term "stripped peneplain," nevertheless connotes a condition that from the nature of things must be almost impossible of attainment.

The character of the rock-floor on which the Oamaruian rests possesses a far-reaching significance. When many observations are placed on record as to the contour of the floor on which the basement beds of the Oamaruian rest we shall be able to speculate on the configuration of the maritime lands of older Cainozoic times with a confidence we do not now possess.

Art. 6.—*Note on the Hanging Valleys of the Upper Rangitata Valley.*

By R. Speight, M.Sc., F.G.S., F.N.Z.Inst., Curator of the Canterbury Museum.

[*Read before the Philosophical Institute of Canterbury, 7th September, 1921; received by Editor, 31st December, 1921; issued separately, 1st February, 1923.*]

Plates 8, 9.

The question of the origin of hanging valleys has attracted so much attention, and their investigation has resulted in the expression of such divergent opinions by experienced observers, that the present author ventures to submit a note on his observations on this landscape-feature in one district of the mountain region of New Zealand. As a result of repeated excursions he has traversed all the main valleys of the Canterbury rivers and their chief tributaries to their sources, some of them many times, and also paid visits to the fiord region of Otago, as well as to several valleys of Westland once exposed to ice-action; and he should therefore be in a position to consider the arguments advanced by earth-morphologists whose experience has been chiefly gained in the mountains of the Northern Hemisphere.

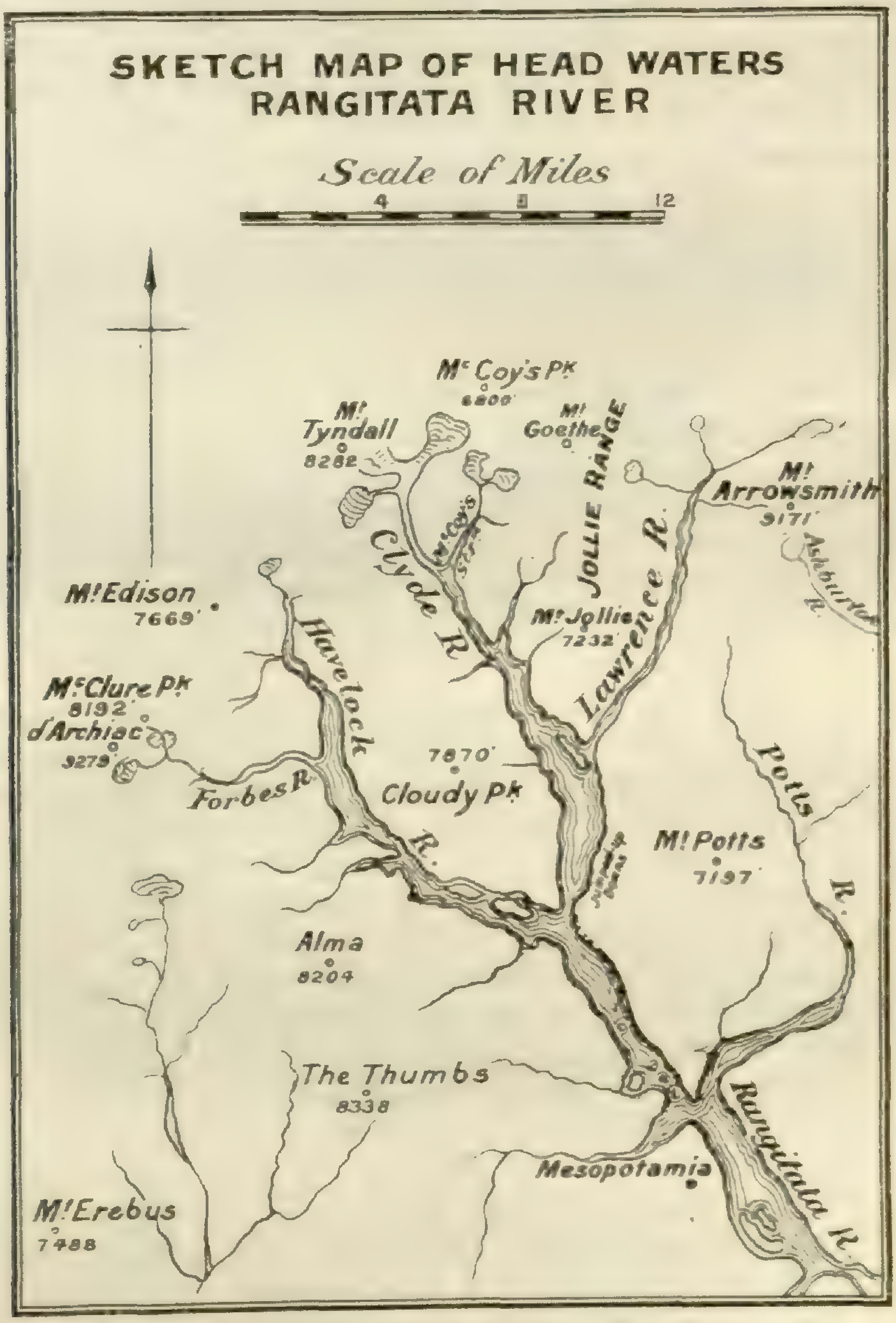
The solution of the problem is no doubt dependent on the efficiency of ice as an erosive agent, a question concerning which there are varied opinions. Authorities like Davis (1909), Gilbert (1904), and Penck credit glaciers with enormous powers of excavation; whereas Garwood (1902, 1910), Freshfield (1888), and Bonney — British observers who have had long experience in high glacier-covered mountains and the valleys leading therefrom—maintain that, instead of actively eroding the hollows they occupy, glaciers actually furnish a protection against the more powerful action of running water; and these opinions are supported in America by Fairchild (1905), Russell (1905), and others.

According to the first group of authorities, hanging valleys are due to the greater activity of the ice occupying the main valley in comparison with that in the tributaries, this activity being attributable to the greater volume and thickness of the ice in the former, the result being that the floor of the main valley is overdeepened as compared with that of its tributary, so that when the ice-flood has subsided the tributary river enters the main valley with discordant grade. De Martonne (1910) attributes the formation of hanging valleys chiefly to lateral sapping, though he admits a certain amount of overdeepening, but not on the *bars* (verrous) across the main valley, near which hanging valleys are also found. Certain members of the second group of authorities regard glaciers in the tributary valleys as protecting their floors, while the rivers of the main valley lower their bottoms by normal stream erosion.

A consideration of the satisfactory nature of one or other of these explanations arose during two visits to the upper Rangitata in company with three of my colleagues, when we were fortunate in having ample opportunity of observing more perfect suites of such valleys than it had been my fortune to see previously.

One group of these occurs on the left (eastern) bank of the Havelock River, on the western slope of the Cloudy Peak Range, a spur running from

the main divide between the Clyde and the Havelock rivers, the two main feeders of the Rangitata. Cloudy Peak (7,870 ft.) is a fine rocky mass near the end of the spur, forming a counterpart to Mount d'Archiac (9,279 ft.), which lies just opposite, on the western side of the Havelock Valley, on a spur of the Two Thumb Range (see map). Two of the hanging valleys are in the most perfect condition; they have the characteristic U-shaped cross-section of a glacial trough with enlarged head, and enter the main stream by waterfalls (Plate 8, figs. 1, 2).



A striking feature of the locality, however, is the association with these of other valleys which enter the main valley at grade, and also of cup-shaped hollows, not worthy of the name of "cirque," which are obviously connected genetically in some way with the action of ice. Neither of the main theories advanced by the authorities cited above accounts for their origin satisfactorily, although these explanations may be quite sufficient in other cases.

The other group I refer to occurs in the Clyde and Lawrence valleys, the last-named being the most easterly of the streams which form the Rangitata River. On the western side of the Clyde, on the flanks of Cloudy

Peak Range, is a series of hanging valleys of the initial, simple type, so perfect in arrangement and in features that they might almost be sketches in a text-book ; in fact, the well-known diagram by Davis, so often cited in this connection, might serve as an illustration of them. I have, unfortunately, no photograph of them. Farther up the Clyde are other valleys of the more developed type seen on the Havelock. I had a better opportunity, however, for examining closely those occurring up the Lawrence Valley. This is a most remarkable valley for showing the remains of glaciation in their most perfect form. Old terminal moraines forming complete dams across the valley, except where breached by the river, lateral moraines, faceted spurs, and other evidence of glacier-action occur, almost as fresh as if they were formed yesterday. The only remnant of the glaciers responsible for them is the small valley glacier, nearly a mile in length, at the head of the river, and small cliff and corrie glaciers on the shady south-eastern slopes of the Jollie Range, which flanks the valley to the north-west—these glaciers now occupying the upper parts of the hanging-valley basins which were excavated at the time of the former ice-flood.

From six to nine miles above the junction of the Lawrence with the Clyde occur three of these hanging valleys in perfect state of development (Plate 9, figs. 1, 2), discharging into the main valley by waterfalls. These valleys are of the well-matured type. Associated with them are hollows similar to those in the Havelock. The series is, however, more complete, so that every stage occurs between the incipient shell-shaped depression and the maturely developed hanging valley ; and the association seems strongly to suggest that the same causes operating now will in process of time produce the matured hanging valley from these hollows, without calling in the overdeepening effect of the main-valley glacier.

Before dealing with this question, however, it will be best to give a brief summary of the general geological conditions of the area under consideration.

The rocks in the valley of the Havelock consist of greywackes and slaty shales, the latter approaching a true slate in character with slightly lustrous cleavage-surfaces, but with the cleavage always parallel to the stratification. In the Lawrence Valley the rocks are more truly greywackes, of texture varying between the coarse-grained type and the fine black slaty variety. Owing to the proximity of the area to the Mount Potts fossil-beds in Rocky and Tank gullies, the matrix of which is similar to the rocks encountered at the head of the main river, it must be concluded, tentatively at all events, that the strata are of the same Trias-Jura age. The submetamorphic character of the strata appears more pronounced towards the west—that is, towards the main divide at the head of the Havelock and Clyde rivers—and also towards the proximal end of the Two Thumb Range in the neighbourhood of Mount d'Archiac.

The beds have a general northerly strike, with slight local variations on either side of this mean, but in the Lawrence district the direction is more commonly N.E.–S.W. The angle of dip is generally high.

The geological history of the area is analogous to that of other parts of the Southern Alps—viz., that after a long-continued period of sedimentation during Mesozoic times the beds were folded up into a mountain-chain of a somewhat simple Alpine type ; this was reduced to a peneplain at the end of that era, covered with a discontinuous veneer of Tertiary sediments, and raised at the close of the Tertiary era into an upland, which during its elevation and subsequently was exposed to vigorous stream and glacier erosion. The original streams which established themselves on the surface appear to have been consequent, with general

directions across the strike, but their positions have been modified by the formation of structural basins and lines of tectonic weakness, so that there are departures from this general arrangement. However, in the upper reaches of the valleys the control of the grain of the country on the direction of the rivers appears more complete, so that there is a pronounced tendency for the tributaries and also the headwaters of the main rivers to develop their valleys along the strike of the beds, and especially along the strike of their weaker members. Thus it is that the heads of all the main rivers of central and northern Canterbury have an almost identical arrangement. The directions of the Waimakariri and its tributary the White River are reproduced almost exactly in the Havelock and its tributary the Forbes. The Lawrence, too, has developed parallel with the strike, a tendency which is very pronounced in its higher reaches. The Clyde, however, runs across the strike, maintaining the original direction taken by the river on what was in all probability the old peneplain surface. Emphasis is here laid on the control exerted by the direction of the stratification on that of the rivers, since the same dominating influence is to be observed in the formation of the hanging valleys.

It is fairly evident that before the onset of the Pleistocene glaciation the drainage had arrived at a stage of early maturity, and after the area has experienced the modifying effects of this glaciation the present tributaries still show an accordance in grade with that of the main valleys. No doubt filling-up of the valleys with the waste deposited from overcharged streams may have tended to mask any discordance, but in the absence of any sign of this whatsoever it is reasonable to conclude that if it occurs beneath the veneer of waste it must be very slight or it would show somewhere. It is only in the middle and upper reaches that hanging valleys occur, and they are but slightly developed in the former section of the river's course. This suggests that the former glaciers, apart from their abrasive action, did not modify the shape of the floors of the valleys as much as has been generally supposed. I do not mean by this that I consider glaciers incompetent to do so, but in the case of the Canterbury region of the Southern Alps this has not taken place to any great extent. The absence of *profound* modification may be accounted for by supposing the duration of the ice-advance to have been short, but due consideration should also be given to the possible obliteration of the traces of glaciers by the action of frost on the mountains farther east.

In the upper reaches, besides the chief tributaries, numerous smaller ones enter the main valley in perfect accordance, and associated with both of these are hanging valleys. It is this association which is difficult to account for on any theory of differential erosion in the main valley as compared with that in the tributary. If one tributary has had its lower reaches removed and the floor of the main valley adjacent thereto lowered so that its junction is discordant, why has its neighbour, placed in an analogous position, not been similarly modified? There is no difficulty, however, as far as this point is concerned with those valleys which have had their discordance reduced in post-glacial times.

I might also say here that there is the entire absence of the development of the glacial stairway in the valleys of Canterbury, although they appear such a striking feature of the valleys of the European Alps and of other countries. There is nothing here analogous to the cascades in the floor of the Ticino Valley as described by Garwood (1909), or the breaks in the floors of the Alpine valleys with the paternoster lakes on the flat shelves as described by Nussbaum (1910). Even in the Sounds region, with one or two striking examples to the contrary, this feature is only occasional.

The explanation which credits the formation of hanging valleys to deepening by rivers while the tributaries are protected by ice also fails, since there is almost entire absence of evidence of deepening, but strong evidence in favour of aggradation. In no case that I am aware of, where a glacier at present reaches the level of the valley-floor, is the stream deepening its bed in front of the glacier-face; in every case the stream is overloaded with sediment, and is aggrading rather than eroding its bed.

These two hypotheses, therefore, do not afford a satisfactory solution of the problem as far as hanging valleys in the region under consideration are concerned. The suggestion made by the present author is that hanging valleys are at times due to progressive head-erosion of the rocks along belts of structural or lithological weakness.

The hanging valleys in the Havelock district are certainly associated with such belts, and have been eroded principally along the strike of the beds. This is clearly seen in that valley whose head is in the vicinity of Cloudy Peak (Plate 8, fig. 1). Cup-shaped hollows in an earlier stage of development are associated with these more perfect forms, an instance of which is given in Plate 8, fig. 2, to the left of the typical hanging valley. If sapping-back of the head-wall along a belt of weakness should occur here, then the typical form would be developed; and if the mouth or lip over which the water falls into the main valley were marked by the presence of a hard rock or bar of more resistant material, then the discordance would be perpetuated: whereas if the stream issuing from the tributary glacier, or from the tributary valley after ice had disappeared, established itself on an easily eroded bed, then the floor would rapidly be adjusted to the main valley.

These small valleys with grades adjusted posterior to the glaciation are entirely distinct in origin from the main tributaries whose valleys were formed in preglacial times, and which have maintained their accordance. The process of adjustment of the grade in post-glacial times is well illustrated by the photograph of the hanging valley in Plate 9, fig. 2.

In the Lawrence Valley there are excellent examples of the influence of structure on these elevated glacial troughs. Plate 9, fig. 1, gives an illustration of a valley developed along the line of strike; the direction of stratification clearly shows in the picture. In Plate 9, fig. 2, is a similar valley whose lip has been eroded across the strike; but at the back of the picture the development of a trough parallel to the strike is quite apparent, a result being produced analogous to the development of a subsequent stream drainage parallel to the strike. The form which now ensues is a kind of double-headed valley. In the incipient hollows alongside these typical valleys, and grading into them, as regards their main features the same process is to be seen, but the result is not yet so pronounced. The lengthened member of the double-headed trough often forms a pass between adjacent and parallel main valleys.

The fact that so many of the hanging valleys have been eroded on the strike of the beds results chiefly from the fact that the main river directions were initially determined across it. Thus the remarkable and regular series on the west bank of the Clyde are arranged at right angles to the Clyde for this reason; but where the strike-direction varies locally, and also in the higher reaches of the rivers where the tendency of the main stream is to set itself parallel to the strike, the hanging valleys across the strike are increasingly numerous.

If such valleys arise from the development of glacier-filled hollows the level of the lip will be controlled initially by the height at which

such commence to form. On passing up a valley glacier these hollows are observed first of all at considerable elevations above the glacier, on the fringe of the area which is being glaciated. The hollows there formed are generally small in size, but as one goes up the glacier they become bigger. Intercalated with them may be actual tributary glaciers, in many cases occupying the floors of the valleys of the tributaries of the old river-system. Their surfaces will be accordant with that of the main ice-stream, though their beds may be discordant. If the ice disappeared these might form hollows with a moderately defined lip, but the load of waste might completely mask it if the discordance were small. However, tributaries, distinct from these, may occur which do not join the main stream at surface grade, but cascade in as icefalls. Compare, for instance, the Ball Glacier with the Hochstetter Icefall on the Tasman, and the Cockayne Glacier with the Heim on the Lyell. The latter member of these pairs would no doubt leave hanging valleys were the ice to disappear, and yet they would not be dependent for this feature on differential erosion.

Such elevated hollows are enlarged by glacier erosion, chiefly by the sapping-back of their heads till they may contain glaciers of tolerable size. The erosion of the lip of the hollows does not appear to be at all marked, either as the result of glacier erosion or subsequent stream-action. The fact that the lip is so markedly preserved in many cases is rather a testimony to the inefficiency of stream erosion as compared with glacier erosion, at all events under certain conditions. In some cases, no doubt, the bar at the lower end of the cirque is deeply incised, generally as a result of structural weakness, and the tributary may enter the main valley at grade, and this may account for the occurrence of discordant and accordant minor tributaries.

The possibility that hanging valleys might be eroded along a belt of weak rocks was considered by Davis (1900, p. 283), but he decided against it even in the critical case of the Linth Valley, leading into the Wallen See. But he evidently considers it a possibility in connection with corries, for he says, when dealing with these basins on page 305, "Unless the erosion of the corries has been guided by differences in rock-structure there does not seem to be reason for their possessing a basined floor at this stage of development; but if a change of climate should now cause the trunk glacier to disappear, while many of the blunt-headed branches remain in their corries, each little glacier thus isolated will repeat the conditions of erosion above inferred for the trunk glacier." Davis thus contemplates that rock-structure may have an important effect on the formation of corries, but it is hard to see why the formation of an extended basin should be delayed till change of climate. Why should this process not go on at the time when the trunk valley is filled with ice?

Some such mode of formation of hanging valleys is described by Russell (1905, p. 79). He says, "It is evident from the inspection that typical mountain-side glaciers are engaged in excavating depressions for themselves, which at an early stage in the process have the essential features of cirques, and at a later stage develop a valley of the typical U-shaped cross-profile, flat bottom, &c., with a cirque at its head. These glaciers may be said to burrow into the mountain-side by headward extension, chiefly, as is judged, by 'quarrying.' The lower limit to which they are able to excavate their beds, or the local base level, is determined by melting. A glacier of the type referred to deepens its bed to this

level, and, given time enough, extends it headward until a flat-bottom trench is produced. Should the glacier then melt, a hanging valley would be left, the mouth of which would open out on the slope on which the glacier originated." This statement seems to fit the conditions here admirably; but in the case under consideration the backward sapping will be more rapid if carried on along the strike of beds of structural or lithological weakness.

An important circumstance to consider is the cause which determines the height at which hanging valleys lie above the floor of the main valley. If they are to be attributed to overdeepening of the main valley or to cutting back the lower courses of tributaries, then the heights should be accordant in a general sense, unless there is some special reason to the contrary. Thus the Stirling Fall and the Lady Bowen Fall, of Milford Sound, show some approximation in height, but this is entirely different from that of Harrison's Arm or Sinbad Valley—all reference to elevation being made, of course, to the bottom of the sound as the datum-level. If these hanging valleys are due to differential erosion, then their preglacial form and gradient must have been quite different This general accordance in height is tacitly admitted by the diagrams used by Davis to illustrate his position. He also says (1909, p. 340), "The depth of glacial erosion in the main valley is roughly indicated by the discordant altitude of the hanging lateral valleys, as well as by the height of the main-valley-floor steps; but in both cases allowance must be made for the glacial erosion of the lateral valleys, or of the bench at the top of the rock-steps." I think from this that he evidently would expect all hanging valleys in one reach of the main valley to be approximately accordant.

Both Gilbert (1904, p. 154, fig. 77) and Garwood (1910, p. 329) certainly indicate that the floor of hanging valleys in the same main valley are occasionally accordant, so that it is possible that the objection made here as to the variation in level does not always hold; but if we admit the correctness of Russell's statement cited above, this, too, will result in approximate accordance of the lower lips of a suite of hanging valleys of approximately the same size.

If it be granted that some hanging valleys may be developed from corrie basins, then the height of their lips will be dependent on the level at which corries can form. Geikie (1902, p. 233) notes that this is related to the height of the snow-line, and its level will, in general, be accordant under similar conditions of slope and aspect in the same region; therefore the accordance in the level of the floors of corrie glaciers and the hanging valleys developed from them is what we might reasonably expect, even if they are not to be regarded as due to the overdeepening of the main river-valley. The general lowering in height of the corrie-level when followed westward up the valleys of Canterbury is what might be expected, since the snow-line falls the nearer approach is made to the main divide. It may be noted here that the table given by Penck, and quoted by Geikie on page 233 of the work just cited, as to the level at which corrie-lakes occur in New Zealand—viz., from 600 to 1,200 metres—gives too restricted an upward range, since well-developed cirques and lakes are found at heights exceeding 4,500 ft. (1,400 m., approximately).

Hanging valleys of a type similar to those occurring in the upper Rangitata can be seen in the other valleys of Canterbury—as, for example, on the higher levels on both sides of the Bealey River, in the Waimakariri between the mouths of the Bealey and Hawdon, also in the Wilberforce

FIG. 1.—Hanging Valley, Havelock River; Cloudy Peak in the background: showing valley of simple type eroded along the strike of the beds.

FIG 2.—Hanging Valley, Havelock River: showing typical valley with incipient hollow to the left.

Fig. 1.—Hanging Valley, Lawrence River: showing development parallel to the strike of the beds, also the lip of the valley in process of being reduced.

Fig. 2.—Hanging Valley, Lawrence River: showing the valley, originally established across the strike, developing another head parallel to the strike; the lip is in a further stage of reduction.

Valley. It cannot be urged that these have been formed by sapping-back along lines of structural weakness, since some of them lie across those lines, but the method of formation is analogous to those in the Havelock. Some of them certainly show a tendency to enlarge their heads along the strike when their general direction crosses it at right angles.

Although it is here urged that many of the hanging valleys of the alpine area of Canterbury are not to be attributed directly to differential erosion, there are some cases which may be explained in that way. Andrews Creek, a tributary of the Waimakariri on the north side, between the junctions of the Hawdon and Poulter, may be attributed to this cause, since there is good evidence of overdeepening in this portion of the Waimakariri Valley; but the possibility of the discordance being due to tectonic movements in this case must not be overlooked, though I do not think it probable.

There are other cases, however, which need special consideration. The formation of Arthur's Pass is most easily explained by supposing that it is due to two hanging valleys which have sapped back along the strike of the beds, one from the west-coast side and the other from the Bealey side of the range, and the drainage has ultimately been captured by the former, leaving both ends of the valley in a hanging condition. An exactly analogous case occurs in Browning Pass—not the well-known pass at the head of the Wilberforce, but one which leads from the valley of the White River, one of the feeders of the Waimakariri. Another type of hanging valley near the main divide is to be seen in Browning Pass itself; also in Walker's Pass, at the head of the Hawdon; and again on the western side of the upper Waimakariri River to the south of Mount Armstrong. One description applies in all these cases.

The main stream comes from a northerly direction parallel to the strike of the beds, and flows along the floor of a characteristic deep glacial trough. The walls, notably the western, are precipitous, and streams sometimes cascade over them from hanging-valley mouths. The floors of these hanging valleys cut across the strike, but they have been reduced to such an extent that they furnish fairly easy routes across the main divide to the valleys of the western slope, and the streams occupying them are partially or wholly diverted to the west, as in the case of Browning Pass.

The marked discordance in these cases is to be attributed to the facility with which stream and glacier erosion has proceeded along the strike, so that overdeepening has taken place in these cases, whereas erosion across the strike has been slow. The erosion of the main valley was in all probability due to stream-action initially, but serious modification of the valley has followed, and the present landscape-features are those attributable to ice-action rather than to stream-action. It is conceivable, however, that stream erosion may maintain a steep-sided valley in these cases, since the beds dip at high angles and hard bands occurring at regular intervals in the greywacke series help to maintain that approach to perpendicularity which was impressed on the valley-walls by ice-action.

At various places in the above discussion I have suggested that the modification of the valleys of the Southern Alps by glaciation has hardly been of the profound order originally indicated by Hector and Haast, and endorsed by later geologists, including myself. My reasons for doubting the statement are—

(1.) The general absence of discordance in the grade of the tributaries at the point of junction with the main streams.

(2.) The possibility of attributing hanging valleys to causes not demanding profound deepening of the main valley.

(3.) The comparatively slight modification of many of the spurs reaching down into the main valley. Truncation and partial truncation are admitted, but this does not demand any abnormal change.

(4.) The difficulty of restoring the preglacial stream-system if profound modification be granted, though the restoration is easy if the modification has been slight. This reason has certainly no great weight of itself, but taken in conjunction with others it is of some importance.

(5.) The thickness and extent of the morainic deposits are not such as one would expect had the valleys been modified profoundly, this necessitating the removal of an enormous volume of rock. In the Mackenzie country, near Lake Coleridge and the gorge of the Rakaia, in the valley of the Ashburton near Lake Heron and Hakatere, and at other places, the morainic material is a veneer resting on older river-gravels, or on Tertiary and other beds, rather than a massive deposit. The area covered may be large, but the total volume of such deposits bears no comparable relation to the amount of material which would have to be removed were the modification by glaciation at all great, and certainly not so much as would be necessary if the hanging valleys had been formed entirely by overdeepening of the main valleys. Of course, a good deal of the solid taken away must have been in the form of flour, sand, and gravel; still, the amount of coarse fragmentary matter should be greater had such excavation been done by ice.

In conclusion, I wish to say that the object of this note is to draw attention to the possibility of processes other than overdeepening of the main stream having been responsible for the formation of hanging valleys. No doubt certain of these are due to this cause, but not all, and each case should be considered on its merits in view of the possibility of more than one cause operating.

Note.

A recent visit to the Wakatipu-Wanaka district has impressed me with the fact that local circumstances must be carefully considered when advancing an explanation for the formation of hanging valleys, and that, while some may reasonably be attributed to overdeepening of the main valley of a preglacial stream-system, other hanging valleys must be credited to causes which have no connection with this previous drainage.

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ART. 7. —*Some Remarks on New Zealand Calliostomidae, with Descriptions of New Tertiary Species.*

By H. I. FINLAY, M.Sc.

[*Read before the Otago Institute, 8th November, 1921; received by Editor, 5th December, 1921; issued separately, 8th February, 1923.*]

Plate 10.

AMONGST the fossil shells from Dowling Bay (see p. 106 of this volume) was a small trochoid form which could not be placed in any New Zealand species so far described. Its appearance was, however, reminiscent of a shell found at Ardgowan, near Oamaru, and on looking up references it was found that this shell also was undescribed. It was evidently a *Calliostoma*, but no species of this genus is mentioned in Suter's Ardgowan list, the only trochoid shells given being two new species of *Basilissa*, so that either this shell had not been collected or it had been placed in *Basilissa* and not yet described. Several fragments of the same species were found at Target Gully, also one or two fragments of another *Calliostoma*. In Suter's Target Gully list the only shells that might be connected with these species are *Trochus tiaratus* Q. & G., *Calliostoma* n. sp., *Basilissa* n. sp. Now, although *Trochus tiaratus* Q. & G., has a superficial resemblance to the Ardgowan shell, it is totally different when the details of the aperture are compared, but a small fragment of the body-whorl might easily be mistaken for this *Trochus*. The author has never found *T. tiaratus* Q. & G. at Target Gully, nor does it occur in material of Marshall's collecting, deposited in the Otago University School of Mines, nor amongst the Target Gully specimens in the Geological Survey collection. It is first mentioned in this connection by Marshall and Uttley (1913), who (due probably to Suter's identification) record it from Awamoa, Target Gully, Ardgowan, Pukeuri, and the Devil's Bridge—every locality they visited—and mention it (*inter alia*) as not having previously been recorded below Pliocene beds. In a later publication (1914) the same authors give a fuller list, revised by Suter, and in it are recorded *T. tiaratus* Q. & G. and *Trochus* n. sp. In a still fuller list (1915, p. 378) Marshall records only *T. tiaratus* Q. & G. Finally, in the list in *N.Z. Geol. Surv. Bull. No. 20* and *Pal. Bull. No. 8* the final record is *T. tiaratus* Q. & G. and *T. chathamensis* (Hutt.). The latter can be easily identified, and certainly does occur there. Park (1918, pp. 88, 90, 93) listed *T. tiaratus* from Awamoa, Ardgowan, and Pukeuri also, but these records are only copied from Marshall and Uttley's original paper; and, in answer to a letter, Mr. Marwick wrote to the author that "there do not appear to be any specimens [of *T. tiaratus*] in the Survey collections from any Oamaruian localities."

Now, in *Pal. Bull. No. 8*, 1921, which is as complete an account as possible of the molluscan lists from all the New Zealand localities, the

occurrence of *T. tiaratus* is mentioned in seven different localities: Bryant's Farm (Gisborne), Scinde Island, Petone, Wanganui, Motunau beds, Cape Wanbrow, and Target Gully. All these except the first and last are Pliocene or Pleistocene. In the first case an impression only was found, and this is marked "doubtful"; in the last case it appears to the author that *T. tiaratus* is a very doubtful record, probably copied, without revision, from incorrect early lists. Besides these occurrences, there are two more in the *Trans. N.Z. Inst.* The first (Thomson, 1920, p. 393) is in the Pliocene Greta beds, and the second is in a final list given by Speight (1917, p. 355) at the close of his paper on the Trelissick beds, but it is not mentioned in any of the component lists elsewhere in the paper, and has probably crept in as an error. From this evidence it is seen that there is as yet no published reliable record of *T. tiaratus* Q. & G. in any New Zealand beds older than the Pliocene, and that this species, therefore, is not a Miocene form. Suter's record from Target Gully was probably based on a fragment of one of the new *Calliostoma* species described in this paper.

This leaves us with *Calliostoma* n. sp. and *Basilissa* n. sp. In the Otago School of Mines collection are some small fragments labelled in Suter's handwriting, "*Calliostoma*, very likely n. sp., Target Gully," and these are probably the original specimens, for the first mention of a *Calliostoma* from this locality occurs in *Bulletin No. 20*, and Mr. J. Marwick wrote saying, "As regards the *Calliostoma* n. sp. of Park's list, I do not know what shell is referred to, but it is probably one of your species so labelled by Suter previous to his introduction of *Basilissa*. I have not come across it in any of Park's collections." What there is left of these shells agrees perfectly with fragments in the author's collection from Target Gully, and there is no doubt that Suter was correct in referring this shell to *Calliostoma*. This species, though identical with the Dowling Bay shell and a form rather rare at Ardgowan, is different from the other species mentioned from Target Gully, which is also rather common at Argdowan. Inquiry made of Mr. Marwick elicited several interesting points about this second form. He managed to place the shell as identical with specimens in the Geological Survey collection from Target Gully and also Ardgowan, and labelled by Suter "*Basilissa* n. sp." In this collection was also another shell, which is Suter's second species of *Basilissa* from Ardgowan, and which differs from all the author's specimens. Regarding *Basilissa*, Mr. Marwick says, "It is hard to understand why Suter classed these shells as *Basilissa*. In the "*Challenger*" *Report*, Zoology, xv, p. 96, Watson, the author of this genus, gives the following description:—

"*Basilissa:* Shell conical, carinated, umbilicated, nacreous; last whorl sinuated above; pillar straight, and in its direction but little oblique, thin, hollowed out above, in front hardly toothed, but at the base strongly angulated; mouth rhomboidal, outer and inner lips do not approach one another nor are united by any palatal callus. *The special feature of this genus is the sinus in the outer lip near its insertion.*

"There is no trace of this sinus shown by the growth-lines, nor is there an umbilicus, so I think the classification as *Calliostoma* is much more suitable."

There is one more record of *Basilissa* that the author has come across, and that is a shell in the Otago University School of Mines collection, labelled again in Suter's handwriting, "*Basilissa* n. sp., Target Gully.

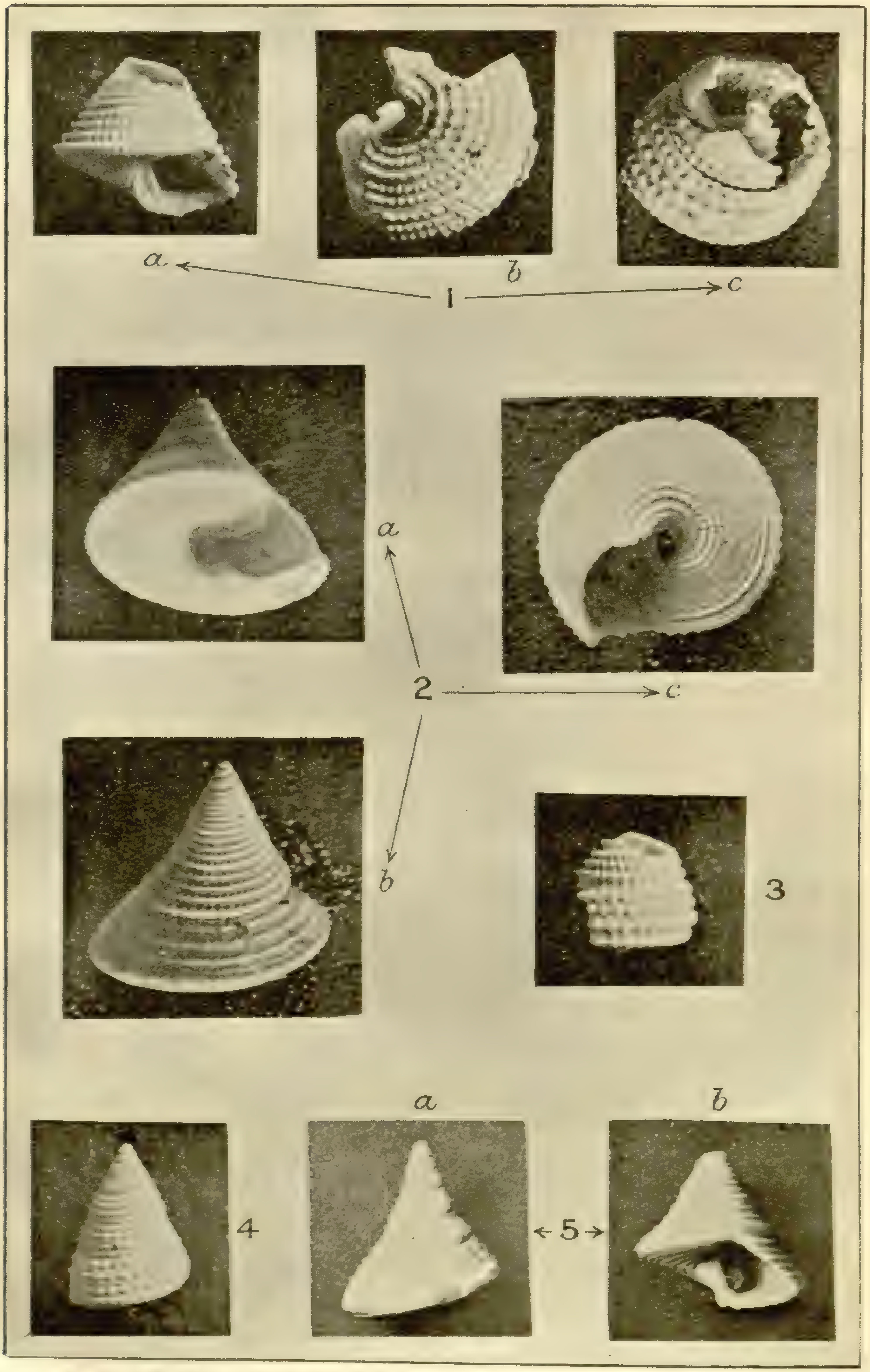

Fig. 1, *a*, *b*, *c*.—*Calliostoma suteri* n. sp. Holotype (*a*), Ardgowan, and two paratypes (*b*, *c*), Target Gully. × 3.
Fig. 2, *a*, *b*, *c*.—*Calliostoma suteri fragile* n. subsp. Holotype (*a*) and two paratypes (*b*, *c*), Ardgowan. × 3.
Fig. 3.—*Calliostoma cancellatum*. Holotype, Ardgowan. × 3.
Fig. 4.—*Calliostoma marwicki*. Holotype, Ardgowan. × 3.
Fig. 5, *a*, *b*.—*Calliostoma undulatum*. Holotype (*b*) and paratype (*a*), Castlecliff. × 2.

Face p. 100.]

I have specimens, also collected by Professor Park." But unless the contents of the tube have been changed this identification is worse still, for the shells in the tube belong to one of the new species named by Suter himself in the Target Gully list as "*Bezanconia* (*Ataxocerithium*) 2 n. spp."

We can therefore safely say that, so far, *Basilissa* Wats. has not been correctly recorded from New Zealand, and this genus must be omitted from our faunal lists.

The foregoing remarks show that *Calliostoma* has been denied its proper place in the New Zealand Tertiary. The author has studied all the available specimens of the genus from New Zealand Tertiary localities (his best thanks are due to Dr. P. Marshall for generously forwarding him all the specimens in his possession), and as a result proposes four new species and one new variety.

Calliostoma suteri n. sp. (Plate 10, fig. 1, *a*, *b*, *c*.)

Shell small, conical, rather solid, imperforate. Closely beaded, subequal spirals present, four strong ones on body-whorl about twice their width apart, with or without a much finer and less strongly beaded riblet intercalated between them; the nodules on lowest rib rather larger but only slightly more numerous than on the upper three. On base there are seven or eight beaded spirals subequidistant, with rarely a few much finer interstitial riblets. Spire straight, apical whorls missing, last whorl rather bluntly angled at periphery, base flatly convex. Suture slightly impressed. Aperture subrhomboidal, oblique, lirate within, sides thick (especially basal one) till near the edge, then narrowing rapidly where the callus stops, to a sharp, crenulate edge. Columella arcuate, oblique, slightly pearly, ending suddenly in slightly reflexed angle with basal lip. Inner lip spreading over umbilical tract as a thin callus, uniting ends of peristome.

Height (estimated), 11 mm.; width, 11 mm. (Imperfect holotype.)

Holotype, from Ardgowan, and several fragmentary paratypes, from Target Gully, in author's collection. Also a specimen, forwarded by Dr. Marshall, from Awamoa, which differs only in its slightly more convex base, due probably to adolescence.

Remarks.—This is the shell named by Suter in the Target Gully list (*N.Z. Geol. Surv. Bull. No. 20*) as *Calliostoma* n. sp.

The author has had an opportunity, through the kindness of Mr. P. G. Morgan, of examining the type specimen of *C. acutangulum* Sut., and the following differences may be noted: The new shell has strong nodules, almost spinose in some specimens, while *C. acutangulum* has them much lower and blunter; not so prominent as the figure (*Pal. Bull. No. 5*, pl. xi, fig. 3) makes them appear. Those on the third rib (counting from the apical end) are more than one and a half times as numerous as those on the first rib; the second and fourth ribs having an intermediate number. This fact, together with the backward slope of the nodules on the upper three ribs and the distinctly forward slope on the lowest rib, gives the sculpture a much less regular appearance than in *C. suteri*. Distinct beading on the basal ribs occurs only near the umbilical area, whereas all the basal spirals in *C. suteri* are strongly granose. The suture in *C. acutangulum* is more prominent, due to the greater distance between it and the highest rib. Mr. J. Marwick, who also compared the two shells, agreed with the author, and added, "I think if we had better specimens from this locality that more differences would be found—for

example, in the disposition of the columella, which is somewhat obscured in the holotype of *C. acutangulum*. Specific rank for your shell is, in my opinion, justified."

The shell is named after New Zealand's pioneer in modern conchology.

Calliostoma suteri var. **fragile** n. var. (Plate 10, fig. 2, *a*, *b*, *c*.)

1918. *Basilissa* n. sp. (Sut.), *N.Z. Geol. Surv. Bull. No. 20*, pp. 90, 94.

Shell thin and fragile, imperforate. Protoconch of a little over one whorl, granulated, not shining (indicating probably a previous horny envelope), nucleus globose and generally a rather prominent varix just before brephic stage, which commences with two spiral carinae, and many unequal longitudinal ribs; during second post-embryonic whorl a third carina develops on upper shoulder, and a fourth at suture below. On all following whorls there are four main spiral ribs, the lowest being strongest and margining suture, in gerontic stage further lesser spirals develop; the largest fragment has eight unequal ribs on last whorl, the four main ribs three or more times their width apart. The first five post-embryonic whorls also axially ribbed, axials slanting irregularly backward, thin and sharp, nodulous where they cut the spirals. They become weaker, and faint growth-lines take their place on sixth whorl, but nodules persist, about sixty on ninth whorl. Base irregularly sculptured, but generally three close, smooth spirals at edge, very near nodular peripheral rib, innermost usually much the strongest; then a space of about quarter width of base almost smooth, then about four more strong, nodulous spirals round umbilical tract: the whole base crossed by parabolic growth-lines. Spire acute, almost twice height of aperture, outlines straight above, becoming rapidly more concave below: whorls nine to ten, body-whorl sharply angled at periphery, base flatly convex. Suture generally marked only by prominent peripheral rib and smooth concave infrasutural space. Sides of aperture uniformly thin, nacreous and lirate within. Columella oblique, with slight tubercle at base, even less reflexed and notched than in *C. suteri*. Inner lip extending as a slight callus over umbilical tract; not crossing parietal wall. Umbilical depression very slight.

Height, 11 mm.; height of aperture, 4 mm. Diameter—major, 11 mm.; minor, 9 mm. Holotype: Diameter—major, 15 mm.; minor, 13 mm. (fragment of a large specimen).

Holotype and many imperfect paratypes from Ardgowan in author's collection. Also found at Pukeuri (specimen in Dr. Marshall's collection) and at Target Gully.

Remarks.—Mr. Marwick reported on this shell, "This is the *Basilissa* n. sp. of Park's Target Gully list, and one of those in his Ardgowan list. This shell has the secondary moniliform spirals coming in on the later whorls, as is the case with *C. acutangulum* Suter; but its concave outline, sharper beads, thinner spirals, and the tendency to a smooth band on the base render it more easy of separation than is the case with the previous species."

Calliostoma cancellatum n. sp. (Plate 10, fig. 3.)

Shell fairly solid, imperforate, outlines pagodiform. Only two whorls of the unique specimen remain, but the sculpture of these is very distinctive. Both spirals and axials are very strongly developed, sharp and thin, giving

a prominent cancellated appearance to the shell. There are four of these spirals on each whorl, with no interstitials, but the lowest is weakened and on the spire-whorls hidden by the whorl below, so that these whorls have only three spirals. Axials, though strong, only half the width of spirals, straight between suture and rib above and below it, but decidedly sloping backwards elsewhere, forming laterally compressed nodules at intersections with spirals, those on lowest rib of body-whorl smaller but equal in number to those on upper ribs. Base with one very prominent moniliform rib just inside periphery, then a totally smooth concave space, then four nodulous umbilical ribs, the inner two being much closer and finer, but, as body-whorl is missing, this is probably not the true basal sculpture. Suture rendered false-canaliculate by the prominence of the spirals. Sides of aperture thick, columella less oblique than in *C. suteri*, little reflexed, but with a rather prominent basal notch.

Height (estimated), 10 mm. ; width, 6 mm. (Imperfect holotype.)

Holotype, from Ardgowan, in the author's collection.

Calliostoma marwicki n. sp. (Plate 10, fig. 4.)

1918. *Basilissa* n. sp. (Sut.), *N.Z. Geol. Surv. Bull. No. 20,* p. 90.

Shell fairly solid, acutely conical, imperforate. Protoconch lost in the unique specimen; first remaining whorl with two carinae, one at periphery, the other margining suture below, and having distant, small, hollow nodules; traces of a line margining upper suture, and this on the next whorl becomes another spiral rib almost equal in size to the lower two; all the ribs strongly nodulous. At the same time a faint line margining lower suture begins to develop, and on following whorl becomes a fourth prominent nodulous rib; thin and sharp axials now begin to connect nodules. The main ribs continue subequal in size, but later on a thin interstitial riblet is intercalated between each pair, axials become suddenly obsolete, and, though nodules of the three upper main spirals remain in backwardly sloping, rather distant rows, those of lowest rib and interstitials increase in number till the proportion is about 3 : 2. Base with strong moniliform spiral rib inside periphery, with a linear smooth rib between the two, then a slightly concave space with about nine smooth low spirals, then three prominent moniliform umbilical ribs. Spire high, two and a half times height of aperture, slightly convex. Whorls about eight, base very slightly convex. Suture excavated in upper whorls, slightly impressed in lower, submargined below and above. Aperture subrhomboidal, outer and basal lips thin, straight, meeting at a sharp angle; columella almost straight, slightly twisted, rather strongly reflexed and basally notched, inner lip spreading as a callus over the parietal wall but not reaching outer lip.

Height, 7·5 mm. ; width, 4·5 mm.

Holotype, from Ardgowan, in the collection of the New Zealand Geological Survey.

Remarks.—This shell is an extreme form of *Calliostoma*, and approaches certain sections of *Cantharidus*. Mr. Marwick mentions (*in litteris*) that this is the second *Basilissa* sp. of Park's Ardgowan list, and that the basal ornamentation shows it is a close ally of *C. cancellatum* (*vide ante*), though the spire sculpture is very different.

The author's thanks are due to Mr. P. G. Morgan and Mr. Marwick for permission to describe this shell, and it is named in honour of the latter gentleman, whose help and criticism have been invaluable.

Calliostoma undulatum n. sp. (Plate 10, fig. 5, *a*, *b*.)

Shell conical, imperforate, rather fragile. Protoconch lost and spire much eroded in both specimens seen, but spire-whorls roundly carinated a little above suture, giving the shell a slightly undulatory outline, and bear at first only three nodulous spirals, with later on a much finer nodulous riblet intercalated between each pair, and there is indication that in fully adult specimens the principal spirals may increase to four. The top spiral margins the suture above, and the spirals increase in size from this suture downwards. The lowest spiral does not margin the suture, and there is no strong nodulous rib at the periphery, its place being taken by about four fine almost smooth spirals, which lie between the lowest main rib and the first distinct moniliform basal rib—only about two of these riblets can be seen above suture on spire-whorls. Rather blunt and inconspicuous axials connect nodules on upper whorls, but their place is taken later by fine growth-lines. Base with about nine subequal not prominent moniliform ribs, generally with a much finer thread intercalated between each pair. The two inmost basal ribs closer together, but otherwise umbilical tract not prominently marked. Whorls about eight, base almost flat. Suture slightly excavated, margined below. Aperture trapezoidal, outer and basal lips thin and straight, meeting at a blunted angle of about 70°. Columella straight, only slightly reflexed, covered with callus which does not extend over the parietal wall, basal notch slight.

Height, 11 mm.; width, 9·5 mm. (Imperfect paratype.)

Both specimens are from Castlecliff, near Wanganui, and are in Dr. P. Marshall's collection. The better-preserved one is chosen as holotype. The species is very close to *C. pellucidum* Val., which differs, among other things, in its coarsely-ribbed periphery and sharper outlines near apex.

The species of *Calliostoma* just described fall into a rather well-defined group so far as New Zealand representatives of the genus go. The members agree in having small shells, a rather acute spire and sharp peripheral angle, small protoconch, and only slight development of umbilical callus; but the prominent feature is their sculpture. They all have typically three or four main spirals and secondary interstitials, these being generally cancellated on earlier whorls by thin, sharp axials. Three fossil members of this group have already been described—viz., *C. hodgei* (Hutt.), *C. ponderosum* (Hutt.), and *C. acutangulum* Sut. *C. hodgei* is very similar to *C. suteri fragile*, but comparison with the type of *C. hodgei* in the Otago University Museum, kindly lent to me by the curator, Dr. Benham, and another specimen borrowed from Dr. Marshall's collection, showed the following differences: While the new shell has four spirals on all but the first two post-embryonic whorls, the lowest being prominent, strongly and closely nodulous, *C. hodgei* has three main spirals for at least four whorls after the protoconch, increasing to about six subequal main ribs on the body-whorl, the upper five with rather distant nodules, but the lowest rib on the later whorls is practically smooth. Also, for adult specimens of about eight whorls, *C. hodgei* is twice the size of *C. suteri fragile*, and has a straight and much more callused columella. *C. ponderosum* (Hutt.) has three, increasing to about six smooth spirals, and is a much larger shell than any others in the group. (For comparisons with *C. acutangulum* Sut. see remarks under the diagnoses of *C. suteri* and its variety *fragile*.)

The eight members of this group can be tabulated thus :—

A. With three main spirals on most whorls :	
(*a.*) Spirals smooth, shell large	*C. ponderosum.*
(*b.*) Spirals nodulous :	
(i.) Axials very conspicuous, cancellating the spirals ..	*C. cancellatum.*
(ii.) Axials inconspicuous :	
Periphery with several fine, blunt riblets below a stronger, nodulous rib	*C. undulatum.*
Periphery with one smooth, sharp rib ..	*C. hodgei.*
B. With four main spirals on most whorls :	
(*a.*) Spire concave, especially in lower whorls, sculpture delicate	*C. suteri* var. *fragile.*
(*b.*) Spire straight or lightly convex :	
(i.) Suture marked, nodules on third rib most numerous	*C. acutangulum.*
(ii.) Suture inconspicuous :	
Nodules on the two lowest ribs in the ratio 2 : 3, spire high as in *Cantharidus*	*C. marwicki.*
Nodules on the two lowest ribs subequal in number, spire-angle much wider	*C. suteri.*

These eight shells show a very close similarity to one another, and it may be questioned whether most of them do not belong to one very variable species, which alters its habit remarkably under different conditions. The author does not think this view tenable, especially in view of the occurrence of different members at the same locality and the same member in very different localities, but what is practically certain is that, in New Zealand, *Calliostoma* was, during the Oamaruian, in a highly plastic evolutionary state, and produced several members closely similar at the time, but whose Pliocene and Recent descendants differ widely. It must be borne in mind that the possibilities for variety in *Calliostoma* are slight : the ornament is very simple, so that small differences in it, coupled with other differences such as are found in the spire and columella, rank as high as conspicuous differences would in a complicated sculpture. *C. hodgei*, though distinct from *C. suteri fragile*, probably evolved from it, and very likely a branch of the same stock gave rise to the Recent *C. pellucidum* (Val.), and perhaps also to *C. selectum* Chem. This tri- or tetra-lirate group seems to have died out in New Zealand, for all our Recent shells have polyspiral sculpture, though their embryonic whorls show their probable descent. It remains to be seen in the future whether the component members of the group will be of use for zonal purposes, for the author has not at present sufficient material from enough localities to settle this point.

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Art. 8.—*Fossiliferous Limestone at Dowling Bay.*

By H. I. Finlay, M.Sc., and F. H. McDowall, M.Sc.

[*Read before the Otago Institute, 8th November, 1921; received by Editor, 5th December, 1921; issued separately, 8th February, 1923.*]

Plate 11.

The occurrence of a limestone at Dowling Bay has long been known, but no fossils have yet been recorded from it. A few species were found on the occasion of a visit of the Otago University geology class, and, at the suggestion of Dr. Benson, we undertook to make as complete a collection of fossils as possible, and to describe the locality.

The place was visited by Blair (1879), who found five seams of limestone which he stated might be of use for building purposes. Analysis, however, showed that varying amounts of sand (from 3 to 28 per cent.) were present, and the rock has been rejected as a source of lime, though it has been used for building-stone in Port Chalmers.

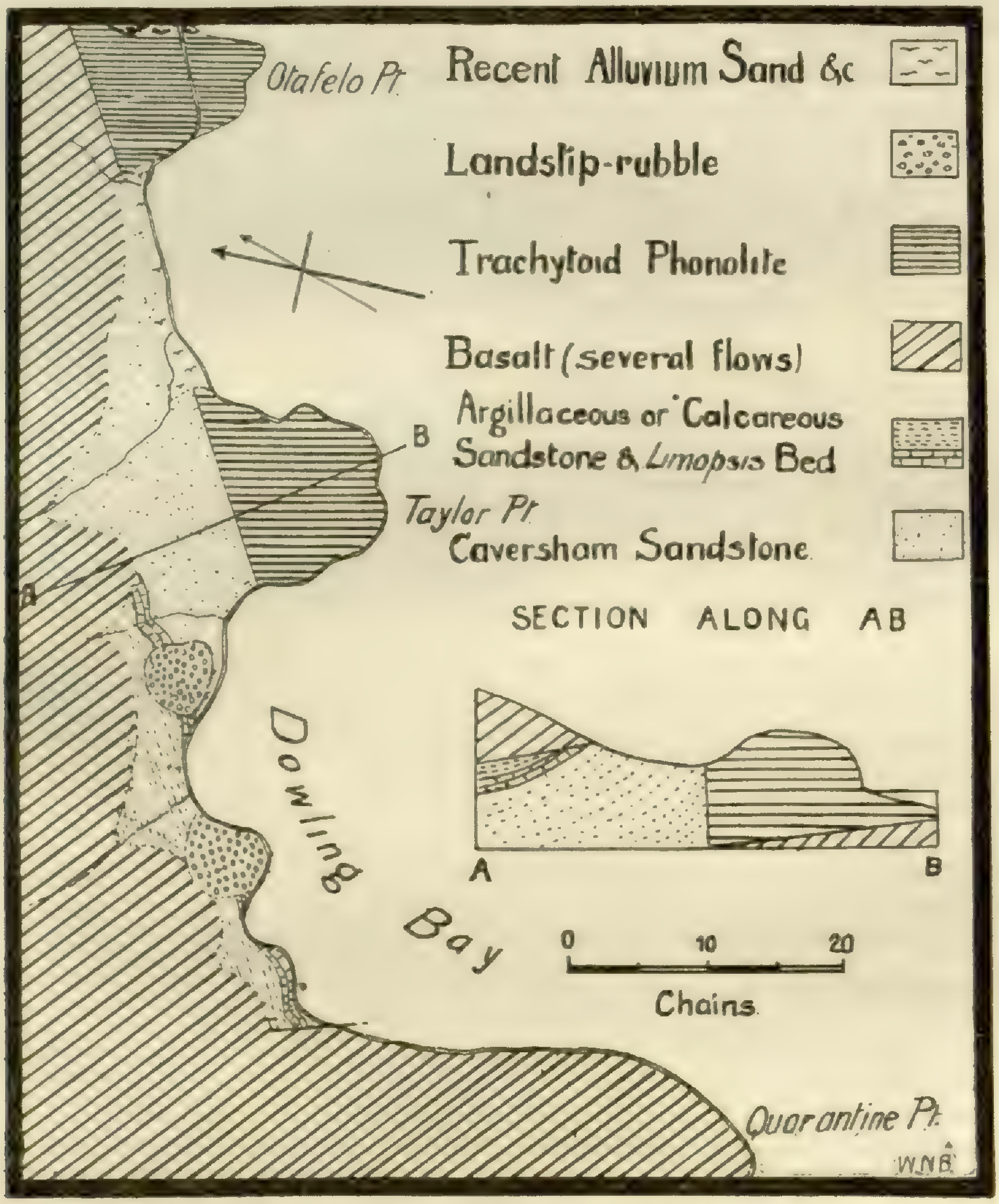
There is no record of any other examination of the locality till it was inspected by Morgan (1919). He found the strikes ranging from S. 30° W. to W. 10° N., with westerly and northerly dips of from 25° to 60°. He also noticed the extreme variation in the composition of the rock.

As may be seen from the map, the outcrops of sedimentary deposits are limited on one side by the coast-line, and on the other by an overlying series of basalt-flows. The marine beds have been exposed by the removal of the basalt by erosion, and except along the sea-border are almost completely covered with soil. It is thus difficult to determine the line of separation between the basalt and the calcareous sandstone, but a series of springs was taken as giving evidence of the dividing-line.

Fossils were obtainable only from a road-cutting at the western end of Dowling Bay, the remainder of the fossiliferous strata being obscured by two masses of landslip rubble and soil. The *Limopsis*-bearing limestones, which are the most prominent parts of the outcrop, were found to dip about W. 10° N. at angles varying from 36° to 45°. The fossiliferous layers are scattered through a thickness of about 160 ft., with no well-defined order of occurrence. The limestone varies largely in appearance and character from a hard grey to a softer black rock, and in small laminae is even of a shaly character. The *Limopsis* bands are up to 1 ft. in thickness, while those in which *Flabellum* and *Turritella* are abundant have a thickness in some cases of several feet.

In a cliff on the road between the two heaps of rubble, blue-grey calcareous sandstones are seen to rest on the fossiliferous beds, and these in turn on yellow sandstone like that at Caversham. Here the dip of the grey limestone is 35°. From the second rubble-heap to the mass of phonolite at Otafelo Point the sandstone is yellow, unfossiliferous, and stands in high cliffs, though without much sign of stratification. The beds here appear to dip vertically, and it was noticed that this displaced stone is in line with the fault that cuts off the phonolite. The phonolite adjacent to the faults is fractured and broken, especially the northern mass at Otafelo Point.

The section along AB indicates the relative position of the beds. It can be seen that the fossiliferous limestone overlies the Caversham sandstone without unconformity, and therefore, if the age of these beds can be determined from palaeontological evidence, a limit is placed on the age of the Caversham sandstone. It may be noted also that somewhat similar fossiliferous limestones appear among the volcanic rocks of Sandymount, on the southern side of the harbour, and these also appear to be underlain by the Caversham sandstone.



Map of Fossiliferous Limestone at Dowling Bay.

The trachytoid phonolite, mapped as such by Dr. Marshall in 1906, has been described for us by Dr. Benson in the following terms: "Microscopically this rock resembles the phonolite of Logan's Point, near Dunedin, but has a rather greater grain-size. The dominant mineral is a soda sanidine, which occurs in small phenocrysts up to a length of 0·8 mm., and much more abundantly in narrow laths in general fluidal arrangement, but with sheaf-like radiating groups. No trace could be observed of anorthoclase, or, indeed, of any polysynthetically twinned feldspar. Interstitially there is a small amount of zeolite material with bright polarization colours, probably replacing nepheline, which latter could not be distinguished in

the unstained section. The pyroxene is a pale weakly pleochroic aegyrine augite, occurring rarely in small idiomorphic phenocrysts, but generally in minute prisms without terminal faces, or in less regular wisps. Magnetite occurs rather more abundantly than is the rule in Dunedin phonolites, ranging from very small grains to those about 0·1 mm. in diameter. Possibly this mass of phonolite is the continuation of the much thinner flow of phonolite described by Dr. Marshall (1914) near the base of the great series of flows at North Otago Heads—*i.e.*, about a mile farther to the north-east. Several intermediate outcrops of phonolite have been found suggesting this."

The Dowling Bay limestone is rather rich in shells, but, unfortunately, most of them are either rolled or fractured. The fossils have a characteristic black or rusty crystalline appearance. In many of them the ornamentation is obscured, and frequently much excavation of the matrix is necessary before any identification can be made. The limestone is generally compact, the shells mostly occur in thin carbonaceous beds which do not split out easily, and the exposure of complete specimens is of rare occurrence.

It has been possible in almost every case to compare the species identified from Dowling Bay with actual specimens from Oamaru, especially Target Gully, in the author's cabinet, and so it is hoped that as few errors as possible have been incurred.

A definite idea of the horizon of this bed may be obtained most readily by tabulating records and estimating percentages after the methods of Marshall (1919, p. 247) and Thomson (1920, pp. 389 *et seq.*).

Dowling Bay Fossils.	1.	2.	3.	4.	5.				6.	7.	8.	9.	Remarks.
					a.	*b.*	*c.*	*d.*					
Calliostoma suteri n. sp.*	..	..	..	..	N	..	N	N	..	..	..	..	
Turritella cf. *patagonica* Sow.	..	..	..	..	×	..	..	×	..	..	..	..	
—— *rosea* (?) Q. & G. ..	..	..	..	..	×	..	×	×	..	×	×	×	Fragment.
—— *semiconcava* Sut. ..	×	..	×	..	×	×	×	×	..	..	..	..	
Sigapatella novaezelandiae (Less.)	..	×	×	..	×	×	×	×	×	..	×	×	Several.
Crepidula densistria (?) Sut.	..	×	..	..	×	..	..	×	..	..	..	..	
—— *costata* (?) (Sow.)	..	..	..	..	×	..	×	×	..	..	×	×	Fragment.
—— *gregaria* Sow. ..	..	..	..	..	×	×	..	×	×	×	..	..	
—— *monoxyla* (Less.) ..	..	..	×	..	×	×	×	×	×	×	×	×	
—— *striata* (Hutt.) ..	..	..	..	..	×	×	..	×	×	×	..	..	
Ampullina suturalis (Hutt.)	×	..	×	×	×	×	×	×	..	..	..	..	
Cymatium sp. ..	..	..	..	..	..	..	..	..	..	..	..	..	Fragment, but not any N.Z. species so far described.
Epitonium zelebori (Dkr.)	..	..	×	×	×	×	×	×	×	..	×	×	
Fusinus macrotegens n. sp.†	..	..	..	..	..	..	..	..	..	..	..	..	
Aethocola spinifera n. sp.†	..	..	..	..	N	..	N	N	..	..	..	..	Spire-fragment.
Dentalium solidum Hutt.	..	×	×	×	×	×	×	×	×	×	..	..	Many.
Nucula sagittata Sut. ..	×	..	..	×	×	×	×	×	..	..	..	..	Many.
Nuculana semiteres (Hutt.)	×	..	..	..	×	×	×	×	..	×	..	..	
Malletia australis (Q. & G.)	..	..	..	..	×	×	×	×	..	..	×	×	

* Described at p. 101 in this volume—"Some Remarks on New Zealand Calliostomidae, with Descriptions of New Species."

† See description later.

Dowling Bay Fossils.	1.	2.	3.	4.	5. a.	5. b	5. c.	5. d.	6.	7.	8.	9.	Remarks.
Anomia huttoni (?) Sut.	..	..	×	..	×	..	..	×	×	..	..	..	Much-worn specimens. Radiate ribs cannot be seen, but may have been obliterated.
—— *undata* Hutt. ..	..	..	..	..	N	..	..	N	..	..	×	×	
—— *trigonopsis* Hutt.	..	..	..	×	×	×	×	N	×	..	×	×	
Placunanomia incisura (?) Hutt.	..	..	×	..	×	×	×	×	..	..	..	..	Fragment.
Limopsis producta n. sp.	..	..	..	..	..	..	..	..	..	..	..	..	
—— *zealandica* Hutt. (= *L. aurita* of previous lists)	×	×	..	..	×	×	×	N	×	..	×	×	Very plentiful.
—— *zitteli* Iher. ..	×	..	..	×	×	×	×	×	..	..	..	..	
—— *catenata* Sut. ..	×	..	×	..	×	×	×	×	..	×	..	..	
Mytilus huttoni Cossm.	..	×	×	..	×	×	..	×	..	..	..	..	
Pecten polymorphoides Zitt.	..	×	×	..	..	..	..	..	..	..	..	..	
—— *hutchinsoni* Hutt.	..	×	×	×	×	×	..	N	..	..	..	..	
—— cf. *hilli* Hutt. ..	..	..	..	..	..	..	..	..	..	..	..	..	Fragment.
Crassatellites sp. ..	..	×	..	..	×	..	×	×	..	..	..	..	Hinge-fragment. Either *amplus* (Zitt.) or *attenuatus* (Hutt.), not *obesus* (A.Ad.)
Venericardia ponderosa Sut.	..	..	..	..	..	..	..	..	..	..	..	..	
—— *subintermedia* Sut. n. var.	..	..	..	..	×	..	..	×	..	..	..	..	Same as the Target Gully variety.
Lucinida laminata Hutt.	..	..	..	..	×	×	×	×	..	..	..	..	
Divaricella cumingi (Ad. & Ang.)	..	..	..	..	×	×	N	×	×	..	×	×	Several.
Macoma edgari (?) Iredale	..	..	..	..	×	×	..	×	×	×	..	×	Fragment.
Zenatia acinaces (Q. & G.)	..	..	..	..	×	×	×	×	..	×	×	×	
Chama huttoni (?) Hect.	..	..	..	..	×	..	..	×	..	..	×	..	Fragment.
Ventricoloidea vellicata Hutt.	..	..	..	..	×	×	×	×	..	..	..	..	
Chione mesodesma (Q. & G.)	..	..	×	..	×	..	..	×	×	×	×	×	Hinge-fragment.

Column 1.—Wangaloa and Hampden beds. Marshall (1917, p. 451 ; 1919, p. 235).
2.—Waiarekan stage of the Oamaruian.*
3.—Ototaran stage of the Oamaruian.
4.—Hutchinsonian stage of the Oamaruian (Lower Hutchinsonian of Park).
5*a*.—Awamoan stage of the Oamaruian.
5*b*.—Basal stage of the Awamoan (Upper Hutchinsonian of Park).
5*c*.—Ardgowan "shell-bed."
5*d*.—Target Gully "shell-bed."
6.—Kawa Creek beds. Bartrum (1919, p. 104).
7.—Waitotaran stage.†
8.—Castlecliffian stage. Marshall and Murdoch (1920, pp. 120 *et seq.*).
9.—Recent.

* The records in columns 2 to 5*d* are from Park's lists in *N.Z. Geol. Surv. Bull. No. 20 (n.s.)*, pp. 90, 94–96, 97–104. Uttley (*Trans. N.Z. Inst.*, vol. 52, p. 176, 1920) has shown that Park's Upper Hutchinsonian cannot be separated from the Awamoan, and it is here so considered. The Hutchinsonian records in column 4 are taken only from Park's Lower Hutchinsonian lists, but the fauna of his upper beds is listed for comparison in column 5*b*. The letter N in any column denotes a new record made by the author and so far unpublished.

† Taken from various Waitotaran lists in *N.Z. Geol. Surv. Pal. Bull. No. 8*, 1921.

Besides these were several unidentifiable fragments, a few *Balanus* plates and echinoderm spines, very numerous specimens of *Flabellum laticostatum* T.-Woods, and a single *Hemithyris* species, too much worn to be specifically identified, but very similar to *H. nigricans* (Sow.). No traces were found of other brachiopods, though careful search was made.

Over 140 specimens were examined, yielding forty-one species. Twenty-five of these are lamellibranchs, a percentage of 61. This predominance of lamellibranchs shows that the conditions of deposition were somewhat akin to those of some of the Trelissick beds, which contain a very similar fauna (Speight, 1917, pp. 352–55). In view of the correlations made later in this paper, it may be useful to quote Marshall's words, used in connection with the relative poverty in gasteropods often noticed in the New Zealand Tertiary beds: "So far as observations have gone up to the present time, this striking difference does not appear to be due to the depth of the water or any other of the ordinary conditions that control the deposition of sediment" (Marshall and Murdoch, 1920, p. 128). The absence of small gasteropods may be due to bad preservation, or, as shown by the limestone, the prevailing muddiness of the sea-bottom.

As regards relative abundance of species, most of them are sporadic in occurrence, but *Limopsis zealandica* Hutt. and *Flabellum laticostatum* T.-Woods are extremely plentiful. This last point is interesting in view of the fact that the Dowling Bay limestone is the probable equivalent of the Sandymount limestone on the other side of the harbour, which was included by Marshall (1916, pp. 93, 96) in his "younger limestones of New Zealand." The non-occurrence of *Flabellum*, &c., in these limestones is drawn attention to, so it appears that in this respect the Dowling Bay beds are exceptional. A curious point is the complete absence so far of the Toxoglossa—*Turris*, *Surcula*, *Drillia*, *Terebra*, &c., being generally plentiful in the Oamaruian. Here again the fauna agrees closely with that of the Trelissick beds, this absence being commented on by Speight (1917, p. 356). A consideration of the habitats of the Mollusca enumerated leads to the conclusion that the beds were deposited probably at a depth of about 50 fathoms, and this is in accordance with the impure sandy character of the limestone.

There are only three species in the above list peculiar to the locality.* Omitting forms doubtfully identified, also *Pecten* cf. *hilli* Hutt. and *Venericardia ponderosa* Sut., the horizons of which are not definitely known, it can be shown, by using Thomson's method of implication, that the percentage of records in the various stages is as follows :—

Recorded from	Column.	Percentage.
Wangaloa and Hampden fauna	1	22
Waiarekan stage	2	41
Ototaran stage	3	53
Hutchinsonian stage	4	53
Awamoan stage	5*a*	88
Upper Hutchinsonian of Park	5*b*	72
Ardgowan "shell-bed"	5*c*	59
Target Gully "shell-bed"	5*d*	88
Kawa Creek beds	6	50
Waitotaran stage	7	50
Castlecliffian stage	8	31
Recent species	9	30

* Since the above was written the author has found *Limopsis producta* n. sp. also at Target Gully, and fragments of the same *Cymatium* sp. at Target Gully and Pukeuri, so that only one species, *Fusinus macrotegens* n. sp., now remains peculiar to the locality. This strongly supports the correlations here made.

Marshall (1919, pp. 237–47) has discussed reasons in favour of using this Lyellian percentage method of age-determination, also the minimum size of a collection that is of value on palaeontological grounds, and he considers that about forty species give a fair indication of the age of a bed, if one uses the percentage of Recent species. When the collections are small, Thomson (1920, p. 394) considers the relation of the fauna to typical fauna of other Cainozoic stages, rather than the percentage of Recent species alone, but shows that correlation is unduly favoured with a stage, such as the Awamoan, in which a great number of species occur. Now, although the percentage of Recent species at Dowling Bay (30) is below that usual for Awamoan horizons, it is considerably above that for typical lower Hutchinsonian localities (Park 1918, pp. 73–85, 94, &c.), and probably further collecting would raise the percentage of Recent species. If the other percentages are compared it is seen that they point strongly to correlation with either the Upper Hutchinsonian (basal Awamoan of Uttley) or even more with the Awamoan, but not with the Lower Hutchinsonian. That the higher percentage of Awamoan forms is not due simply to the greater number of Awamoan species can be seen by studying the actual species themselves and comparing the percentages of columns 5*c* and 5*d*. It is then at once apparent that the Dowling Bay fauna is essentially the same as that at Target Gully. Only six of the species in the former do not occur in the latter, and three of these are new. Even the percentage of records from Ardgowan, another Awamoan locality, falls far below that from Target Gully. *Calliostoma suteri*, *Aethocola spinifera*, *Venericardia subintermedia* var., *Lucinida laminata*, &c., show a distinctly Awamoan facies, and the whole collection reminds one forcibly of Target Gully. The abundance of the coral *Flabellum* and the presence of echinoderm spines is at first suggestive of Ototaran or Hutchinsonian horizons, but the writer has collected the same species of *Flabellum* rather commonly at both Ardgowan and Target Gully, also spines and *Balanus* plates indistinguishable from Dowling Bay specimens. Also, *Pecten huttoni* Park, fish-teeth, and other corals have not so far been found at Dowling Bay, and these are generally abundant in horizons just below the Awamoan. The brachiopodal evidence, though scanty, is also worth considering. Uttley (1920, p. 176) remarks that "the [*Pachymagas*] '*parki*' band marks a definite horizon, the close of the Hutchinsonian." Now, as noted before, a single species of *Hemithyris* is the only brachiopod yet found at Dowling Bay: there is no sign of the Terebratellidae so abundant in the Ototaran and Hutchinsonian. Considering these facts, we may conclude that the Dowling Bay limestone is on the horizon of either the Target Gully "shell-bed" (Awamoan), or less probably of the glauconitic sandstone that lies conformably beneath it (Upper Hutchinsonian), and suggest that it correlates better with the former of these.

The chief importance of this conclusion lies in the inferences that may be drawn from it regarding the age of well-known formations near Dunedin. An extensive sandstone horizon (Caversham and Waikouaiti sandstones) and numerous volcanic outflows are a conspicuous feature of the geology of the district, and until the last few years the ages of these horizons were very uncertain. Park (1904) referred the Waikouaiti sandstone and the underlying foraminiferal clays simply to the Oamaruian, and placed "the first outbursts in the later period of the Miocene, or in the beginning of the Pliocene." Grange (1921, p. 161) places the lavas as Post-Awamoan, since they rest unconformably on a denuded surface of Caversham sandstone,

which, he believes, extends through the Awamoan. The fact that basalt rests also unconformably on the Dowling Bay limestone shows that volcanic activity did not commence till a considerable time after the Awamoan, for in most localities sufficient time must have elapsed for this limestone (which is the highest marine bed in the district) to have been denuded away altogether, and part of the Caversham sandstone besides.

As regards the Caversham sandstone, the Dowling Bay section presents important fresh evidence, and corroborates views held by some previous observers. The Waikouaiti sandstone, which is believed to be the equivalent of the Caversham sandstone, has not yet been thoroughly investigated, though there are indications that several zones with determinable fossils are present (Park, 1904, p. 422). Thomson (1918), basing his views mainly on the early Tertiary age of Waiarekan horizons and the finding at Waikouaiti of *Waiparia intermedia* Thomson, concludes that "the Waikouaiti sandstone is not Ototaran, but Upper Oamaruian, and may well be Awamoan, and the underlying clays Hutchinsonian." The palaeontology of the Caversham sandstone itself is also very meagre and inconclusive. Grange (1921, pp. 166–67) places it, together with the underlying small greensand bed, as representing Awamoan, Hutchinsonian, and Ototaran stages. It may be noted that the few molluscs found in it agree quite as well, if not better, with the fauna of the Upper Hutchinsonian (basal Awamoan) than with that of the true Hutchinsonian. Grange records *Pachymagas parki* (Hutt.) and Thomson (1920, pp. 375–6) mentions *P. cottoni* Thomson as occurring in the Caversham sandstone, and both these range into the Awamoan. These facts, together with its general poverty in brachiopods, suggest it is of a higher age than Hutchinsonian. On the other hand, it is unlikely that the Caversham sandstone extended beyond the so-called Upper Hutchinsonian, since it lies conformably beneath the limestone at Dowling Bay, for which a low Awamoan age has been suggested. It is not yet possible to make a certain correlation, but the points discussed lead us to suggest that the Caversham sandstone is a basal Awamoan horizon, and that formerly limestones now for the most part eroded off followed conformably and were of the same age as the Target Gully beds. The highest members of the Awamoan series are without representatives near Dunedin, unless they should occur beneath the basalt north of our line of section.

In conclusion, we wish to thank Dr. Benson for drawing the map and describing the rock-section, and also for his kindly assistance and advice in the preparation of this paper.

Limopsis producta n. sp. (Fig. 1.)

Shell moderately large, elongated, and produced posteriorly, thick, convex, with fine radial striae and strong concentric growth-lines. Beak small, pointed, incurved. Anterior end much shorter, with practically vertical slope, dorsal margin straight and slowly descending. Posterior end much produced, and subtruncated, forming a blunt angle. Basal margin broadly curving and horizontal only near posterior end. Sculpture of numerous concentric growth-lines and few radial striae, similar to the

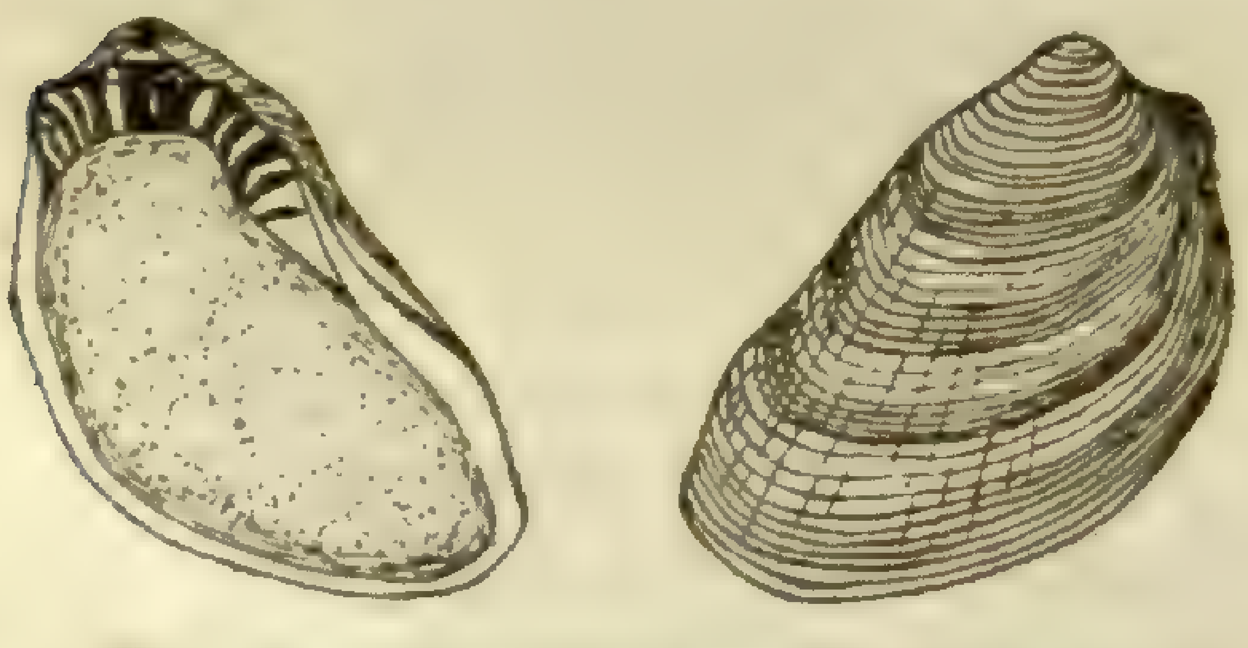


FIG. 1.—*Limopsis producta* n. sp. Natural size.

Fig. 1.—*Fusinus macrotegens* n. sp.
Holotype. Natural size.

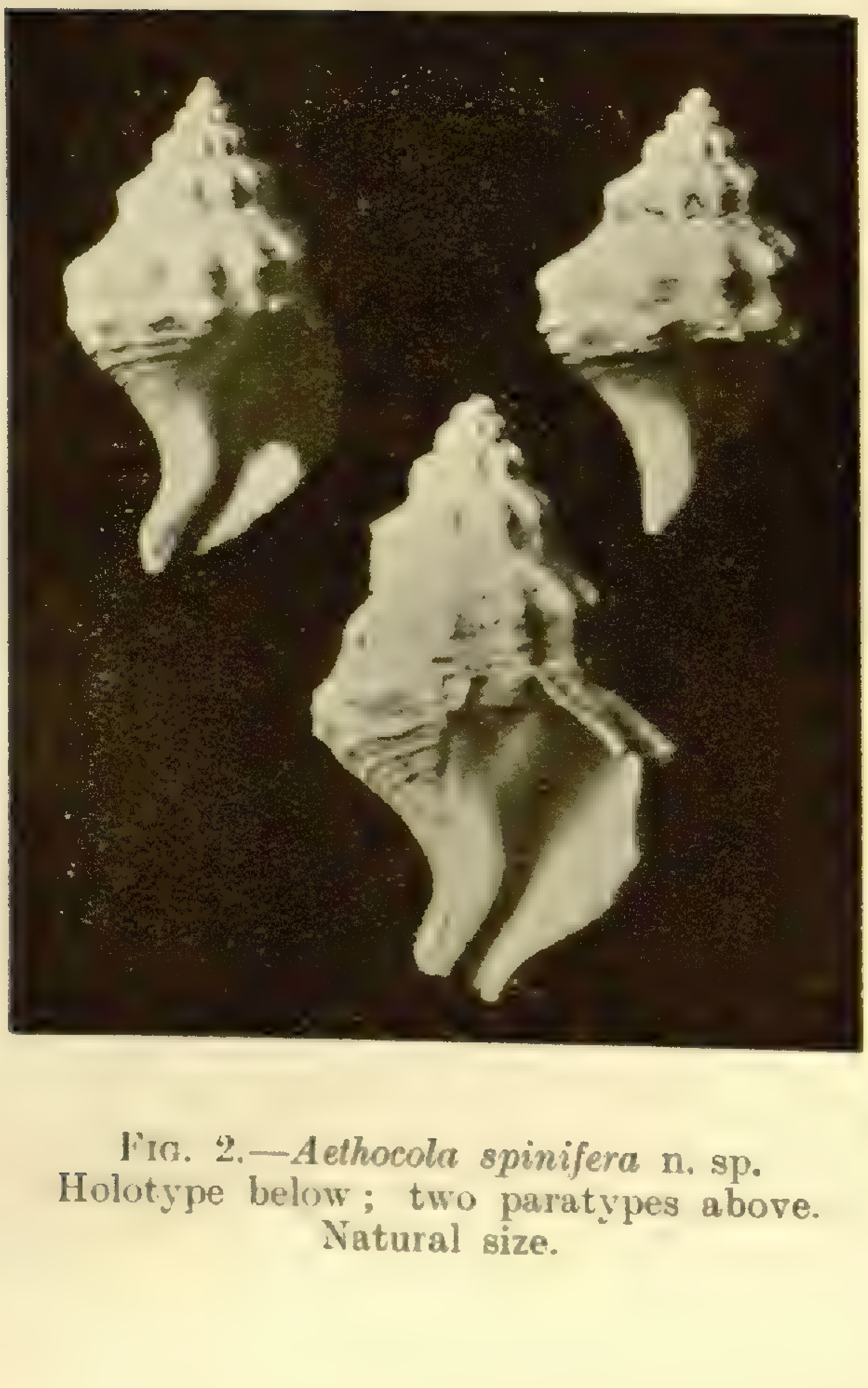


Fig. 2.—*Aethocola spinifera* n. sp.
Holotype below; two paratypes above.
Natural size.

catenate ornamentation of *L. zealandica* Hutt. Margins smooth and bordered by a wide bevel edge as in *L. zealandica.* Hinge-plate strong, with about six teeth on each side, but much obscured by matrix. Ligamental area obscured, but produced on each side into rather prominent ears, the anterior being especially elevated. Interior filled with matrix.

Height, 22·3 mm.; length, 20 mm.; diameter of single valve, 7·5 mm.

Holotype in the author's collection.

Locality.—Dowling Bay limestone (Awamoan).

Remarks.—Closely allied to *L. zealandica* Hutt., seeming at first sight to be only a crushed specimen of that species; but it is difficult to see how the shape could have been so materially altered and the anterior ear so produced without breaking the shell. The specimen is certainly a little distorted, but, even allowing for this, it does not seem referable to any New Zealand or Australian species.

Fusinus macrotegens n. sp. (Plate 11, fig. 1, and text-fig. 2.)

Somewhat like *F. tegens* (Hutt.), but much larger and the sculpture not so bold. Keel tubercles not spinose and serving only to mark posterior ends of rounded axial costae, which are twelve per whorl; interstices a little wider. Body-whorl with about twenty prominent spiral ribs extending

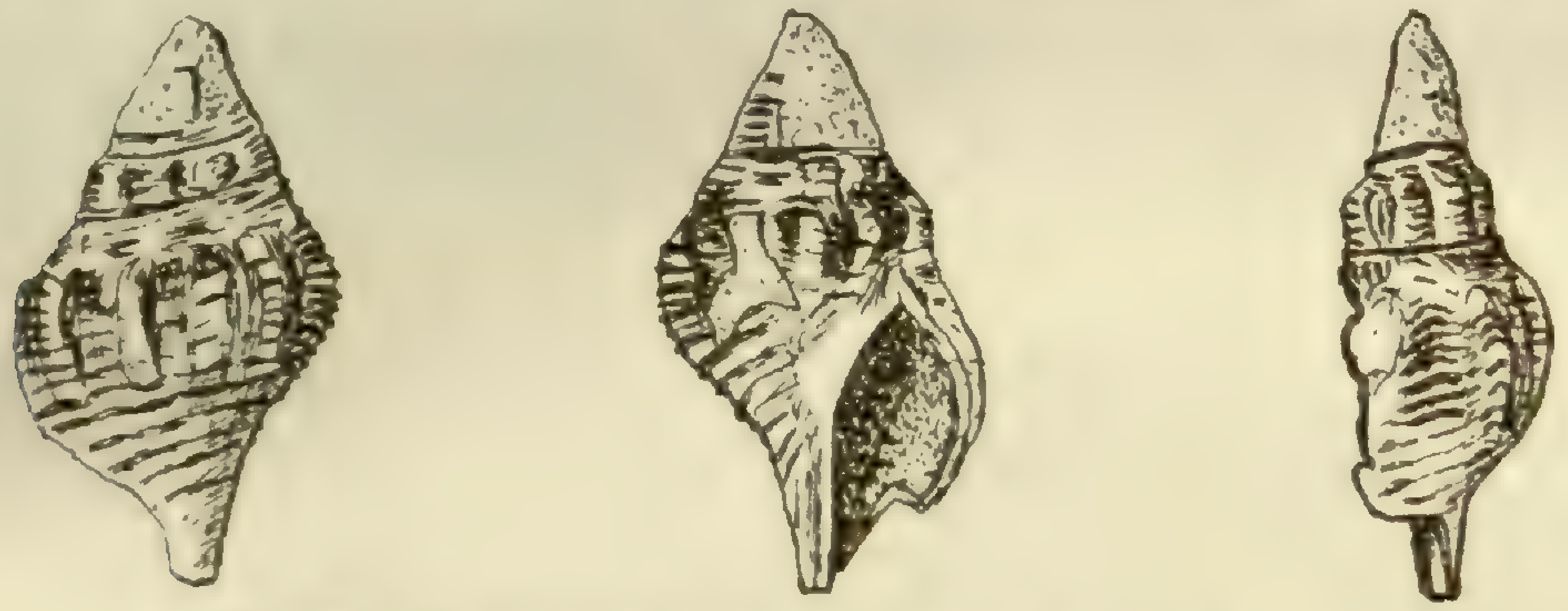


FIG. 2.—*Fusinus macrotegens* n. sp. Natural size.

from suture to neck of canal, anterior ribs getting much wider apart, interstices two to three times width of spirals. Carina on spire-whorls about half-way up the whorl. Outer lip thin, regularly convex, apparently not denticulate inside; a groove separates inner lip from spiral chords. Other details as in *F. tegens* (Hutt.).

Height, 32 mm.; width, 15 mm. (holotype).

The unique holotype is rather crushed, protoconch and small portion of canal broken off. It is in the author's collection.

Locality.—Dowling Bay (Awamoan).

Aethocola spinifera n. sp. (Plate 11, fig. 2.)

Shell moderately large, fusiform, ventricose, strongly shouldered, thin, with short, open, notched canal, turned to the left and slightly backwards. Protoconch minute and smooth, of little more than two whorls, nucleus flattish, depressed. Post-embryonic whorls have strong axial riblets, average about twelve per whorl; the holotype (43 mm. × 23 mm.) has eight whorls, and fourteen axials on the body-whorl. Axials almost vertical, much stronger than in *A. nodosa* (Martyn), vanishing only near canal, interstices a little wider; they arise between keel and suture and continue down to anterior suture; on keel itself they carry strong vertically compressed

spines, continuing on upper keel of biangulate body-whorl, lower keel of which bears a row of similar but smaller nodules. There is a tendency for one or two lirae below this second keel to be slightly spinose. Spiral sculpture formed of fine, unequal, inequidistant threads, stronger and weaker alternating, several more prominent lirae on base; the whole reticulated by fine growth-lines. Spire lower than aperture with canal, outlines straight. Spire-whorls carinated at middle, straight below keel, very slightly concave above it; body-whorl concave between the two keels, rapidly contracted and slightly convex below them. Suture wavy, indistinct. Aperture subvertical, triangulate, fasciole prominent. Outer lip thin, not callous, with only short, linear, and distant lirae. Inner lip rather strongly callous, spreading a little beyond columella and over parietal wall, limited by groove which also truncates basal spirals.

Height (estimated), 43 mm.; width, 23 mm. (holotype).

Holotype (almost perfect) and two paratypes (imperfect) from Ardgowan in author's collection.

Remarks.—Closely allied to *Siphonalia nodosa acuticostata* Sut., for which it was at first taken. Suter's description and figure of the latter do not enable it to be separated from this variety at all easily, but Mr. J. Marwick assures the writer that specific differences may be noted in actual specimens. *S. nodosa acuticostata* Sut. has stronger lirae inside the aperture and a more concave base; its axials carry simple angles at the periphery. Mr. Marwick finds this species also at White Rock River, Pareora; while the author has recorded it from Dowling Bay in this paper, and has specimens from Awamoa and Target Gully.

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ART. 9.—*Early Tertiary Molluscan Faunas of New Zealand.*

By P. MARSHALL, M.A., D.Sc., F.G.S., F.N.Z.Inst., Hector and Hutton Medallist.

[*Read before the Wanganui Philosophical Institute, 27th October, 1921; received by Editor, 3rd December, 1921; issued separately, 8th February, 1923.*]

ON several occasions I have published articles on the fauna of the Hampden beds, as season after season of careful collecting has enabled me to record more and more of the species that occur in that singular collecting-ground. I have ventured to do this because the Mollusca found there are so markedly different from the species that are found in the numerous Tertiary collecting localities in New Zealand.

As mentioned in earlier publications, I have compared the Hampden fauna with that found at Wangaloa mainly because of the distinct Cretaceous facies of some of the fossils found in these two localities. So marked is this Cretaceous facies in the case of the Wangaloa area that nearly all authorities agree in the opinion that the formation is of an Upper Cretaceous age, but not older than the Danian. This opinion is based mainly on the occurrence of *Gilbertia*, *Pugnellus*,* *Perissolax*, and *Heteroterma*, though together with species of these genera there are a number of others that occur widely in the various Tertiary fossiliferous localities of New Zealand.

When a comparison of this Wangaloa fauna is made with that of the Hampden beds it is found that there is a greater similarity with this than with any other Tertiary fauna that has yet been described in New Zealand. Although, however, the resemblances are considerable, the differences remain great, and it is with much hesitation that I have suggested that the two formations are contemporaneous. So great, however, are the differences between these faunas that I have thought it necessary to offer an explanation of them, and to justify the inclusion of the two formations in one and the same geological series. The explanation that I have suggested is based upon the nature of the lithological differences of the materials in which the fossils are embedded in the two localities. At Wangaloa the matrix is a fine sandstone which contains a few grains of glauconite, while at Hampden the rock is an extremely unctuous mudstone which contains abundance of glauconite, and frequent small concretions of pyrite. It is therefore obvious that the Wangaloa deposit was formed in relatively shallow water, and that of Hampden in water of far greater depth. This difference in station necessarily implies also a considerable difference in the nature of the fauna in the two localities, though it is probable that each of them would contain much the same percentage of Recent species.

This suggestion, though apparently simple and evident, has been entirely misunderstood, for Morgan says that Marshall's " view still seems to be that Cretaceous and Tertiary faunas flourished at the same time, the former in deep water, the latter in shallow water, close to the early

* Wilckens, in two bulletins (1921) on the Cretaceous gasteropods of New Zealand, states that the *Pugnellus* from Wangaloa is a young form of *Conchothyra parasitica*. The author does not agree with this.

Tertiary coast-line." It is hard to imagine how such an interpretation could have been given to anything that I have written. Soon after I had begun an investigation of the geology of the Upper Cretaceous and Tertiary formations of New Zealand, more than ten years ago, I was forced to adopt the view that there had been continuous sedimentation in the New Zealand area from the Upper Cretaceous (Senonian) to the Pliocene. In all districts where there has been a close examination of the stratification it is agreed that no hiatus of any importance can be discovered, and in nearly every case it is admitted that the series of younger rocks is not interrupted by any period of discontinuity. From the palaeontological standpoint, however, there have been great difficulties in showing that the faunas run on from one to the other without any sudden change. This results mainly from the fact that the lower beds of this younger series of rocks are generally quite without fossils, or where any fossils are found they are in a state that makes it very difficult to collect and identify them. At the base of the formation there are occasionally a series of fossils that point definitely to a Senonian age, and there is a great deal of difference between this fauna and the one that is next in age, usually in much higher beds. It is only at Wangaloa that a fauna generally recognized as of Danian age has yet been found, though, as is now generally admitted, that of Hampden has close affinities with it. It is to be hoped that future work will discover additional collecting-grounds from these lower members of the series, and thus enable us to find out definitely if faunas with intermediate features have existed, as one would naturally be led to believe from the nature of the stratification. The Hampden fauna, of which a revised list is given below, now contains almost one hundred species of Mollusca, and, as is admitted by Thomson (*Trans. N.Z. Inst.*, vol. 52, p. 390, 1920), it shows much more affinity with the Wangaloa fauna than does any other Tertiary fauna of New Zealand. The chief elements of the fauna that show its antiquity are species of the genera *Trigonia*, *Gilbertia*, and *Dicroloma* (*Alaria*).

Morgan, in his recent notes and review of Suter's lists of New Zealand Tertiary Mollusca, admits that the Wangaloa fauna is of Cretaceous age (*N.Z. Geol. Sur. Pal. Bull. No. 8*, p. 98, footnote), but he also says later that no part of the Oamaru formation contains Cretaceous fossils. This statement certainly requires some qualification when applied to the Hampden fauna. Morgan classes the Hampden beds as of Eocene age (*l.c.*, p. 101), and correlates them with strata in various New Zealand localities. There is, however, no palaeontological basis for this correlation, and it really remains a matter of personal opinion, based on a belief that the beds that are correlated together occur in the same position in the series in the different localities. The Kaiatan stage is said by Morgan to include all of these.

In a paper published in 1920 (*Trans. N.Z. Inst.*, vol. 52, p. 112) I drew attention to the relationship between the Hampden and the Waihao faunas, but stated that up to that time only very small collections had been made from the Waihao beds. During the past summer a collection was made by Mr. Murdoch and myself at McCullogh's Bridge. Some sixty-two species were found, and this collection, combined with those made by previous collectors, gives us a much more accurate knowledge of the fauna of those greensands which lie directly beneath the Waihao limestone, which is admitted by all to be the same horizon as that of the Oamaru limestone itself.

The following is the corrected list of the Hampden fauna, including the species that have been collected during the last four years.

Admete anomala Marshall and Murdoch.
Admete n. sp.
Alectrion sp.
Ampullina suturalis (Hutton).
Ampullina waihaoensis Suter.
Ancilla novae-zelandiae (Sowerby).
Architectonica n. sp.
Atrina sp.
Aturia sp.
Bathytoma sulcata (Hutton).
Belophos incertus Marshall.
Bonellitia aff. *ovalis* (Marshall).
Borsonia zealandica (Marshall).
Bullinella enysi (Hutton).
Cardium sp.
Cerithidea minuta Marshall.
Cerithiella tricincta Marshall.
Circulus inornatus Marshall.
Clio aff. *urenuiensis* Suter.
Cucullaea alta Sowerby.
Cymatium minimum (Hutton).
Dentalium mantelli Zittel.
Dentalium pareorense Pilsbry and Sharp.
Dicroloma zelandica Marshall.
Epitonium gracillimum Suter.
Epitonium parvicostatum Marshall.
Epitonium rugulosum lyratum (Zittel)
Epitonium tenuispiralis Marshall.
Erato antiqua Marshall.
Euthriofusus spinosus Suter.
Exilia waihaoensis Suter.
Fusinus altus Marshall.
Fusinus aff. *bicarinatus* Suter.
Fusinus aff. *morgani* Suter.
Fusinus solidus Suter.
Galeodea senex (Hutton).
Gilbertia tertiaria (Marshall).
Latirus dubius Marshall.
Leptoconus pseudoarmoricus (Marshall and Murdoch).
Lima angulata Sowerby.
Limopsis aurita (Brocchi).
Limopsis catenata Suter.
Limopsis hampdenensis Marshall.
Limopsis zitteli Ihering.
Marginella aveniformis Marshall.
Natica zelandica Q. & G.
Nucula n. sp.
Nuculana semiteres (Hutton).
Ostrea wuellerstorfi Zittel.
Ostrea sp.
Pecten aff. *fischeri* Zittel.
Pecten huttoni (Park).
Polinices planispirus Suter.
Protocardia pulchella (Gray).
Rissoina obliquecostata Marshall and Murdoch.
Sarepta obolella (Tate).
Sarepta solenelloides Marshall.
Sarepta tenuis Marshall.
Seila attenuissima Marshall and Murdoch.
Sinum carinatum (Hutton).
Sinum elegans Suter.
Soletellina sp.
Struthiolaria cincta Hutton.
Struthiolaria minor Marshall.
Submargarita tricincta Marshall.
Surcula aequispiralis Marshall.
Surcula gravida Marshall.
Surcula hamiltoni (Hutton).
Surcula hampdenensis Marshall and Murdoch.
Surcula marginalis Marshall.
Surcula serotina Suter.
Surcula torticostata Marshall.
Surcula sp.
Surcula sp.
Terebra costata Hutton.
Terebra sulcata Marshall.
Trigonia areolata Marshall.
Triphora aoteaensis Marshall and Murdoch.
Turbonilla antiqua Marshall.
Turris complicatus Suter.
Turris curialis Marshall and Murduch.
Turris duplex Suter.
Turris margaritatus Marshall.
Turris nexilis bicarinatus Suter.
Turris politus Marshall.
Turris regius Suter.
Turris reticulatus Marshall.
Turris sp.
Turritella ornata Hutton.
Turritella rudis Marshall.
Turritella symmetrica Hutton.
Verconella nodosa acuticostata (Suter).
Verconella senilis (Marshall and Murdoch).
Verconella turrita (Suter).
Verticordia densicostata (Marshall).
Voluta corrugata Hutton.

This list does not convey much actual information to any but those who are quite familiar with the Tertiary fauna of New Zealand. The following summary of the occurrence of the species will make its nature clearer: 45 per cent. are at present restricted to the Hampden fauna; 11 per cent. have been found also in the Waihao beds but nowhere else; 29 per cent. occur among the seventy species that have been found at Waihao; 20 per cent. occur among the 215 species found at Target Gully; 6 per cent. are of Recent occurrence.

These figures clearly show the following facts:—

(1.) The essential peculiarity of the molluscan fauna of Hampden.

(2.) The close relationship with the Waihao fauna, for 44 per cent. of the fossils that have been found at McCullogh's Bridge on the Waihao have also been found at Hampden.

(3.) Less than 10 per cent. of the 215 fossils that have been found in the Target Gully beds have also been found at Hampden. Since these Target Gully beds rest directly on the limestone, and the Waihao beds lie immediately below it, the fact at once becomes clear that during the deposition of the limestone a great faunal change took place.

(4.) The small percentage of Recent species shows that the Hampden beds are not older than the European Eocene (of which they are in all probability the equivalent); and, as stated elsewhere, the Recent species are represented by very few specimens, and several of them have not been identified with absolute certainty.

The following is a list of the Waihao Mollusca, most of which (actually sixty-one species) were collected in January, 1921, by Marshall and Murdoch from the right bank of the river directly below McCullogh's Bridge. The list includes also a few species that were collected by Uttley in 1912 and by Thomson in 1917, but the three species of *Verconella* given in the list of Suter's identifications of the latter collection are omitted, as the specimens are said to be juvenile, and in our opinion it is not satisfactory to identify species of that genus from juvenile specimens. The lists from which the names of these additional species were taken will be found in the *N.Z. Geol. Surv. Paleon. Rep. No. 8*, pp. 66 and 67.

Ampullina suturalis (Hutton).
Ampullina waihaoensis Suter.
Ancilla novae-zelandiae (Sowerby).
Ancilla waikopiroensis Suter.
Architectonica ngaparaensis Suter.
Aturia.
Bathytoma eximia Suter.
Borsonia brachyspira Suter.
Borsonia cincta (Hutton).
Borsonia rudis (Hutton).
Cerithiella fidicula Suter.
Corbula canaliculata Hutton.
Corbula pumila Hutton.
Cucullaea sp.
Cylichnella enysi (Hutton).
Cymatium minimum (Hutton).
Cytherea sp.
Daphnella neozelanica Suter.
Dentalium mantelli Zittel.
Dentalium pareorense Pilsbry and Sharp.
Dentalium solidum Hutton.
Drillia laevis (Hutton).
Epitonium elatum Suter.
Epitonium rugulosum lyratum (Zittel)
Erato antiqua Marshall.
Euthria stirophora Suter.
Exilia crassicostata Suter.
Exilia waihaoensis Suter.
Fusinus climacotus Suter.
Fusinus modestus Marshall and Murdoch.
Fusinus solidus Suter.
Galeodea senex (Hutton).
Gilbertia tertiaria (Marshall).
Limopsis aurita (Brocchi).

Limopsis zitteli Ihering.
Marginella conica Harris.
Mitra hectori Hutton.
Mitra inconspicua Hutton.
Natica australis Hutton.
Natica gibbosa Hutton.
Natica zelandica Q. & G.
Nuculana bellula (A. Ad.).
Nuculana semiteres (Hutton).
Pecten huttoni (Park).
Pecten waihaoensis Suter.
Sarepta solenelloides Marshall.
Surcula antegypsata Suter.
Surcula ordinaria Marshall.
Surcula pareoraensis Suter.
Surculu serotina Suter.
Terebra sulcata Marshall.
Trigonia ? sp.
Triploca sp.
Turbonilla antiqua Marshall.
Turris aff. *altus* (Harris).
Turris bimarginatus Suter.
Turris complicatus Suter.
Turris duplex Suter.
Turris regius Suter.
Turritella aldingae Tate.
Turritella ambulacrum Sowerby.
Turritella carlottae Watson.
Turritella semiconcava Suter.
Venericardia subintermedia Suter.
Verconella nodosa (Martyn) var. extinct.
Verconella turrita (Suter).
Vexillum apicale (Hutton).
Vexillum apicicostatum Suter.
Vexillum linctum Hutton.
Vexillum sp.
Voluta corrugata Hutton.

An analysis of this list of species is of particular interest from the point of view of a demonstration of the affinities of the Waihao fauna. The following summary gives an idea of these affinities: 17 per cent. of them have been found in the Hampden beds only; 44 per cent. occur in the ninety-six species of the Hampden beds as well as various Tertiary deposits; 43 per cent. occur among the 215 species of the Target Gully species; 10 per cent. are of Recent occurrence.

These facts show how much more closely this fauna is related to the fossils of the Hampden strata than to those of Target Gully. In every one hundred species that have been found in the latter locality less than twenty have been found at the Waihao, while double this number of the Waihao species occurs among the one hundred species that have been found at Hampden. On the other hand, the percentage of species that occur at Target Gully is twice as great as the percentage of the Hampden species which occur there. These palaeontological results show clearly that the Waihao beds, though closely related to those at Hampden, are distinctly younger than them—a result that would be anticipated from the stratigraphy, and has already been stated as probable (Marshall, *Trans. N.Z. Inst.*, vol. 52, p. 112, 1920).

The number of Recent species is still so small that the beds should probably be considered as of Upper Eocene age. It is now agreed by all geologists who have studied the Oamaru district that there is no stratigraphical break beneath or above the limestone formation in that district. The study that we have made of the Waihao and of the Target Gully fossils strongly supports that conclusion.

If the fauna of McCullogh's Bridge is a fair sample of the fauna that lived in the Oamaru area immediately before the deposition of the limestone, and if that of Target Gully is also a fair sample of the fauna that existed directly after that material had been deposited, we may rightly conclude that the deposition of the limestone occupied a long period. The time that elapsed was sufficiently long to allow of a large number of species, and even genera, becoming extinct, and of the development (or at least of the migration) of a large number of other species. We may now state with some probability of correctness that the deposition of the Oamaru

limestone commenced in the Upper Eocene and continued until after the commencement of the Miocene period, though correlation with European equivalents may be misleading.

A comparison with the North Canterbury fauna is again suggested by these conclusions. In the typical Amuri limestone no molluscan fossils have yet been found, but in the Trelissick Basin the local representative formation contains a molluscan fauna that appears to be little older than that of Target Gully. Lately some Foraminifera have been found in the typical outcrop of the Amuri limestone, and Thomson states that Chapman, after examining these, has classed the Amuri limestone as of Danian age (Thomson, *Trans. N.Z. Inst.*, vol. 52, p. 350, 1920). It is more than questionable whether the Foraminifera give a more reliable indication of the age of this formation than the Mollusca that were found in the Trelissick Basin. In the overlying Weka Pass stone eight species of Mollusca have been found; all of them are well-known species in the beds that lie above the Oamaru limestone, and most of them have a wide range, though *Euthria media, Struthiolaria spinosa, Turris altus,* and *Dentalium solidum* occur but rarely below the Oamaru stone. The following list gives the approximate occurrence of the eight species:—

Euthria media: Pareora, Waikare, White Rock.
Struthiolaria spinosa: Trelissick Basin, Kakahu (?), Pareora.
Pecten huttoni: Hampden – Awamoa.
Epitonium lyratum: Hampden – Target Gully.
Turris altus: Otiake – Pukeuri.
Dentalium solidum: Waihao – Pukeuri.
Teredo heaphyi: Waihao – Target Gully.
Limopsis aurita: Hampden – Pukeuri.

Hutton mentions an additional nine species from the Weka Pass stone, and they too have an occurrence in strata that lie over the Oamaru stone and in some cases beneath it as well. They are as follows:—

Scaphella elongata: Mount Brown and Awamoa.
Epitonium rotundum: Brighton.
Galeodea senex: Hampden – Awamoa.
Pleurotomaria tertiaria: Oamaru stone.
Aturia ziczag: Wharekuri – Oamaru stone. Identification doubtful.
Lima laevigata: Waihola, Cobden, All Day Bay.
Pecten williamsoni: Mount Brown beds, Tata Islands, Kawa.
Pecten fischeri: Awamoa.
Pecten beethami: Wharekuri – Awamoa.

Thomson (*Trans. N.Z. Inst.*, vol. 52, p. 355) mentions in addition three species of Brachiopods from the Weka Pass stone. They are as follows:—

Aetheia gualteri: Curiosity Shop, Broken River, Waiareka.
Pachymagas cottoni: Main and Upper Mount Brown limestone, Hutchinson's Quarry.
Pachymagas huttoni: Maerewhenua limestone.

An inspection of this list shows that the molluscan and brachiopod faunas of the Weka Pass stone point to an horizon that is certainly not lower than the upper part of the Oamaru stone, and it should therefore be correlated with that horizon. This opinion is based on long experience and many years' collecting in the Tertiary formations of New Zealand, during which time there has been abundant opportunity of gauging the stratigraphical position of various associations of fossils. Knowledge and evidence of this kind must surely be given greater importance than that

which is ascribed to the three species of Foraminifera which Thomson says have been identified by Chapman and are considered by him to indicate an Eocene age. Up to the present time Foraminifera have been collected but little in New Zealand, and unless the particular species referred to by Thomson have a most distinct Eocene occurrence and are absent in all other deposits in New Zealand little importance can be attached to them; and even if these conditions are fulfilled it is doubtful whether the indication of age given by them can stand against that given by the Mollusca and brachiopods, until at least far more extensive collections of Foraminifera have been made in New Zealand.

In the face of such definite indication that the Weka Pass stone and the upper part of the Oamaru stone are of the same geological horizon, Morgan still classes the Weka Pass stone as Eocene and the Oamaru stone as Miocene (*N.Z. Geol. Surv. Pal. Bull. No. 8*, p. 101, 1921). Speight and Wild have conclusively shown that the Amuri limestone and the Weka Pass stone have a conformable contact (*Trans. N.Z. Inst.*, vol. 52, pp. 87, 88, 1918), and this makes it necessary to correlate part of the Amuri stone with the Oamaru stone.

ART. 10.—*Some Tertiary Mollusca, with Descriptions of New Species.*

By P. MARSHALL, M.A., D.Sc., F.G.S., F.N.Z.Inst., Hector and Hutton Medallist, and R. MURDOCH.

[*Read before the Wanganui Philosophical Society, 27th October, 1921; received by Editor, 22nd December, 1921; issued separately, 8th February, 1923.*]

Plates 12–15.

Lippistes benhami Sut. var. **perornatus** n. var. (Plate 15, figs. 6, 7.)

Shell small, subdiscoidal, cancellated, granulate at the crossings, aperture widely expanded; whorls four, rapidly increasing, spire very small, protoconch of about one smooth whorl, the following with three spiral threads, the next strongly angled, with flat shoulder on which spiral threadlets arise; the last very large, angled above, rounded on periphery and base, a distinct carina margining umbilicus, the wide shoulder convexly raised as it curves to aperture; suture deep; sculpture of the last consists of about nine principal spiral cords between shoulder and basal carina narrower than grooves, in the latter are one or more fine threadlets; on the shoulder are nine or ten much smaller undulating threadlets and a number of similar strength within umbilicus, axials of numerous small cords, feeble on shoulder and terminating at basal carina, gradually becoming distant as they approach to outer lip, between these are fine regularly-spaced threadlets, numerous in the wider spaces and all finely granulate at intersection of spirals. Aperture widely expanded, margin continuous, projecting above spire-level and below base, patulous; columella almost straight, stout, concave, inner lip broadly reflected and projecting; umbilicus moderately deep, not broad.

Length in front of aperture, 6 mm.; length through aperture, 10 mm.; width, total, 13 mm.; width of aperture, 9·5 mm.

Locality: Blue clay, Castlecliff. (Marshall.)

Type to be presented to the Wanganui Museum.

There are two specimens, one in perfect condition, the other somewhat worn and the aperture imperfect. It is apparently rare. No doubt it is closely allied to Suter's Recent species from Cape Maria van Diemen, a small, fragile, and semitransparent shell; it differs in the much stouter shell, much greater expanse of the aperture, and its size. We are indebted to Professor Benham for comparing it with Suter's type in the Otago Museum.

Austrotriton neozelanica n. sp. (Plate 15, figs. 4, 5.)

Shell of medium size, spire narrow, slightly longer than aperture and canal, body rather inflated and has a somewhat oblique and distorted aspect to whorls above, canal short and narrow. Whorls six, protoconch missing, succeeding whorls convex, lightly shouldered a little above sutures, later whorls distinctly concave a little below sutures thence convex with a short inward curve to suture below. Sculpture consists of irregular nodular axial ribs and small granular spirals, nodules on spire-whorl strongest on lower third, above this much suppressed, frequently consisting of irregular small tubercules, on periphery of the last they are strong and rounded with a part row of smaller nodules below, absent towards outer lip. Varices about ten, not prominent, on the body there is one in front of aperture and another close behind outer lip; spirals numerous, narrower than grooves and with irregularly disposed small granules. Sutures slightly impressed, undulating. Aperture ovate, small channel above, outer lip somewhat reflexed and with number of denticles within margin, parietal wall deeply excavated, columella narrow, slightly curved forward, callused and with several stout teeth on lower half, canal very short.

Length, 45 mm.; width, 24 mm.

Locality: Target Gully shell-bed, Oamaru.

Type to be presented to Wanganui Museum.

The specimen was submitted to Mr. Charles Hedley, who reports that he is unable to match it with any shell in the Australian Museum. *A. parkinsonius* Perry is recorded by Suter in our Recent fauna.

Syrnola semiconcava n. sp. (Plate 13, fig. 5.)

Shell small, very slender, gradually tapering, slightly curved forward, smooth, imperforate; whorls eleven or twelve, flat or faintly concave, the last shortly rounded at base, sutures distinct, lightly channelled. Protoconch of about two whorls, nucleus heterostrophe. Sculpture consists of minute growth-lines and microscopic spiral striae, the latter present in places only. Aperture very short, outer lip and base imperfect, the latter apparently somewhat expanded; columella short, stout, and with prominent rounded plait above.

Length, 7·5 mm.; width, 1·25 mm.; length of aperture, approximately 1 mm.

Locality: In fine bluish clay, Awamoa Stream, about half a mile inland from the Coast Road, Oamaru.

Type to be presented to Wanganui Museum.

Appears to be quite distinct from other New Zealand forms; the flat semiconcave whorls and narrow lightly channelled sutures readily distinguish it.

Vexillum plicatellum n. sp. (Plate 12, fig. 3.)

Shell small, shortly fusiform, aperture and canal longer than spire, whorls five and a half, slightly shouldered, a little excavate above; suture not deep, rather widely margined below. Protoconch of about one and a half smooth whorls. Sculpture consists of axial riblets and fine spiral threadlets, about twenty axials on the penultimate whorl, narrower than interspaces, always well developed on spire-whorls, variable on the last, feeble in front of aperture and suppressed towards canal; the spirals consist of minute threadlets, usually rather more pronounced anteriorly on last whorl. Aperture slightly oblique, narrow, canal short, columella almost straight, narrowly callused, with four plaits, the lowermost small.

Length, 7·5 mm.; width, 4 mm.

Type to be presented to Wanganui Museum.

Locality: Greensands immediately below the limestone, McCullogh's Bridge, Waihao River.

The material consists of four specimens, one of which is rather more inflated than the others, and the uppermost plait on the columella is indistinct; the species is apparently nearest to *V. apicostatum* Sut. *Vexillum* n. sp. from the same locality is listed in *N.Z. Geol. Surv. Pal. Bull. No. 8*, p. 66, and the above may be the species referred to.

Verconella delicatula n. sp. (Plate 14, figs. 3, 4.)

Shell small, slender, and narrowly fusiform, aperture and canal much longer than spire, attenuated, whorls eight or nine with low rounded shoulder about middle of whorls, between this and suture above sloping straight or slightly concave, and from shoulder to suture below convex, last whorl below periphery rapidly contracted. Sutures not deep. Sculpture—protoconch of about two and a half smooth whorls, apex minute; the following whorls with axial riblets and spiral threads, axials about thirteen on lower whorls, low rounded and wider than interspaces, variable, towards lip and below periphery of the last obsolete, there are strongly marked growth-lines throughout; spiral threads somewhat granular, on spire there are three stouter threads from shoulder to suture below, with one or two minute threads in grooves, above shoulder about seven smaller threadlets, in some a smaller and larger alternating, others uniform, on the last excluding those above shoulder and on beak there are thirteen to seventeen with frequently a minute thread in the groove, on periphery the spirals are more distant, rather stronger and with one or several fine threads in interspaces. Aperture small, oval, continued into a long narrow canal, outer lip imperfect; columella lightly callused, almost straight above, the long beak slightly twisted to the left.

Length, 28 mm.; width, 8 mm.; length of aperture and canal, 16 mm.

Locality: Greensands immediately below limestone, McCullogh's Bridge, Waihao River.

Type to be presented to Wanganui Museum.

The material consists of two specimens, the outer lip of each somewhat imperfect. Its very slender form and sculpture readily distinguish it from *Siphonalia excelsa* Suter.

Latirofusus optatus n. sp. (Plate 12, fig. 2.)

Shell small, fusiform, aperture and canal almost equals spire in length; whorls about seven, "apical coil missing," convex, the last somewhat

inflated at periphery and strongly contracted below, the beak rather abruptly turned to left. Sculpture consists of strong rounded axial ribs and fine spiral cords, axials seven to eight on lower whorls, narrower than interspaces, extending to end of canal and forming a row of curved nodules on beak; spirals small, rather wider than grooves, about eight between outer lip and suture above, strong growth-lines give to spirals a slightly granular appearance. Sutures undulating. Aperture narrowly oval, outer lip uniformly curved, thin and somewhat expanded, columella almost straight, callused and with small tooth at middle, canal anteriorly almost closed.

Length, 11·5 mm.; width, 4 mm.

Locality: Greensands immediately below limestone, McCullogh's Bridge, Waihao River.

Type to be presented to Wanganui Museum.

The shell has some aspects of a *Trophon;* the plait on the columella is not unlike that of *Josepha:* while, on the whole, it appears to have a fair resemblance to *Latirofusus spiceri* Ten.-Woods.

Pagodula vegrandis n. sp. (Plate 13, fig. 1.)

Shell small, fusiform, spire turreted, shorter than the aperture and canal, axially and spirally ribbed, the former continuing to anterior end of canal and the latter forming hollow spines on crossing axials. Whorls six, protoconch of two smooth loosely-coiled whorls, nucleus minute and somewhat oblique; succeeding whorls strongly angled rather below middle, the last below angle rather rapidly contracted to straight and fairly long canal. Sculpture—axials consist of ten prominent ribs on last whorl, narrower than interspaces except on canal where they are separated by narrow grooves; of spirals there are four on the last and two on whorls above, that situate on the angle is much the larger and with prominent spines, above angle smooth, except a small thread margining sutures. Sutures undulating and deep. Aperture small, ovate, continuing into a long narrow canal; outer lip thin, imperfect, columella almost straight and with a narrow callus.

Length, 9·5 mm.; width, 4 mm.

Locality: Greyish sandy clay in cutting on Main Road, Pukeruri.

Type to be presented to Wanganui Museum.

There is a single example only. Its sculpture is characteristic of *Murex,* while the erect form and turreted spire is not unlike *Columbarium.*

Bonellitia hampdenensis n. sp. (Plate 12, fig. 4.)

Shell small, ovate, whorls six, convex, sutures somewhat impressed, protoconch of three smooth whorls, apex minute; succeeding whorls axially and spirally cancellated, the former more pronounced, much narrower than interspaces and curved forward, there are eighteen on last whorl, more feeble on base; spirals consist of small threads, much narrower than grooves, gemmulate on axials, occasionally a minute thread in groove and two or three similar threadlets immediately below sutures, excluding minute spirals, there are seventeen to eighteen on the last and about seven on penultimate whorl; in places well-marked growth-striae appear in the grooves. Aperture nearly equals spire in length, outer lip imperfect, columella slightly curved and with three evenly-spaced plaits, basal lip a little produced and a few small denticles within margin.

Length, 12·5 mm.; width, 7 mm.; length of aperture, 6 mm.

Locality: Hampden.

Type to be presented to Wanganui Museum.

Closely allied to *B. ovalis* Marshall, from Pakaurangi Point; differing in the much thinner shell, more narrow form, and distinctly more slender and more numerous axial ribs.

Fulguraria morgani Marsh. & Murd. (Plate 14, figs. 1, 2; Plate 15, figs. 1–3.)

F. morgani Marsh. & Murd., *Trans. N.Z. Inst.*, vol. 52, p. 138, pl. 7, figs. 12, 12*a*, 12*b*.

Since describing this species additional collections have been made from the Waipipi (Waverley) beds and the Whakino (near Hawera) beds. The specimens obtained prove that those described were not adult, but in the neanic stage of growth; only two examples of the adult form have been found, one from each locality, while examples of the neanic stage are in abundance in the Whakino beds. These exhibit some variation in the more or less numerous axials ribs, and in the more narrow attenuated form of some specimens. The adult has eight or nine whorls, the last fairly large and somewhat longer than the spire; the example from Waipipi has the body considerably longer. The spire is narrow and sculpture similar to that described, the last whorl lightly shouldered, axial ribs somewhat nodular on shoulder, variable, less pronounced or almost absent on approaching anterior end. Margin of outer lip somewhat reflexed, not much thickened, inner lip with a spreading callus, columella almost straight and with five plaits, anterior always small and posterior in one specimen indicated by only a slight bulge.

Specimen from Whakino: Length, 112 mm.; width, 38 mm.; length of aperture, 59 mm. Specimen from Waipipi: Length, 123 mm.; width, 42 mm.; length of aperture, 72 mm.

These specimens to be placed with type in Wanganui Museum.

The rarity of the adult compared with the numerous occurrence of the small specimens is difficult to account for: they are are the same species, differing in stages of growth and exhibiting some variation in form. Those possessing a very narrow attenuated spire of as many as six whorls no doubt indicate a more slender adult form than obtained. Many examples of the neanic stage have the appearance of being fully adult, this being due to the sculpture—the outer lip is margined with an axial rib, and the bevelled edge produces the appearance of complete growth. At the Whakino beach, about half a mile west of the county stone-hauler and tram-line, and between tide-levels, is an exposure exceedingly rich in well-preserved fossil shells. *F. morgani* occurs in fair numbers. The fauna is characterized principally by the abundance of *Glycymeris laticostata* and variety, *Ostrea hyotis*, *Pecten semiplicatus*, *P. triphooki*, *Miltha neozelanica*, *Struthiolaria zelandiae*, *Cardium spatiosum*, and *Dentalium solidum*.

Drillia apicarinata n. sp. (Plate 12, fig. 5.)

Shell small, narrowly fusiform, apical whorls rather attenuated, aperture and canal shorter than the spire; whorls seven or eight, convex; slightly shouldered above middle on spire-whorls, the last gradually contracted to the short canal, sutures somewhat impressed, margined below. Sculpture—

protoconch of about two whorls, nucleus lost, distinctly carinated and with spiral striae only, succeeding whorl with three spiral threadlets and broad rounded axial ribs, the latter nine on a whorl, wider than the interspaces, obsolete on base; of spirals there are about twenty on the last, smaller towards beak and with a minute thread in grooves, on penultimate whorl there are eight spirals excluding threadlets in grooves, the thread margining suture rather prominent and in places a minute thread above it. Aperture small, narrowly oval, posterior sinus not deep, lip simple, columella almost straight, callused, and tapering to beak, which is slightly twisted forward.

Length, 10 mm.; width, 3·25 mm.; length of aperture and canal, 4 mm.

Locality: Waikopiro. (Suter collection.)

Type in Wanganui Museum.

A single specimen only. The late Mr. Suter has it marked "n. sp."

Bathytoma transenna Sut. (Plate 12, fig. 1.)

Leucosyrinx altus Harris subsp. *transenna* Sut., *N.Z. Geol. Surv. Pal. Bull. No. 5*, pt. 1, p. 44.

A collection of fossil shells from the road-cutting at Pukeuri produced examples of a *Bathytoma* which agreed closely with the description of Suter's subsp. *transenna*. An examination of the holotype in the Suter collection proved that it also is a *Bathytoma* and has no relationship with *L. altus* Harris. Other specimens in the collection are two from Petane, similar to the Pukeuri specimens; these have four or five spiral threads on the sloping shoulder of lower whorls of spire, whereas the type has only three as described by Suter; apart from this there is practically no difference. The specimens Suter records from Waikopiro are not *transenna*—he notes the absence of reticulating axial sculpture, and there are other features which distinguish them; they appear to be an undescribed *Surcula*.

To Suter's description of *transenna* we add the following: Shell small, narrowly fusiform, whorls eight or nine, strongly keeled below middle, aperture and canal shorter than spire. Protoconch of about three smooth whorls, the last slightly shouldered, apex narrowly pointed. Aperture narrow, outer lip angled at keel, sinus immediately above; columella with well-developed callus, almost straight in middle, thence twisted and curved to right, tapering and pointed at end.

The above refers to the holotype from Awamoa. Specimens from Pukeuri and Petane have an extra spiral on the shoulder, and frequently the larger thread below the suture is split into two.

The species is allied to *B. albula* Hutt., examples of which from White Rock River most nearly approach it, and might almost be regarded as a transition form.

Surcula protransenna n. sp. (Plate 12, fig. 6.)

Shell small, narrowly fusiform, spire turreted, whorls seven or eight, a strongly projecting rounded keel at middle on spire-whorls, concave above and below, on the last whorl a well-marked concave area below keel followed by a second keel less pronounced, anterior to this rather abruptly contracted; aperture and canal slightly longer than spire. Protoconch of about one and a half smooth whorls, the lower distinctly carinate, apex blunt. Sutures linear, margined above and below, variable, some examples indistinct. Sculpture—spirals of numerous fine lines on keel and above and below it, indistinct in some specimens, on the last whorl usually more pronounced;

axials consist of growth-lines only, variable in strength, arcuate between keel and suture above. Aperture small, ovate, produced into a long canal; outer lip angled at keel, thence concave followed by a convexity, and beneath this rapidly narrowing to canal; columella narrowly callused, straight in middle portion, narrowing and slightly twisted to left.

Length, 13 mm.; width, 5 mm. Another example: Length, 10 mm.; width, 4 mm.

Locality: Waikopiro. (Seven specimens, Suter collection.)

Type and paratypes in Wanganui Museum.

Suter included these specimens with his *Leucosyrinx alta* subsp. *transenna*. Fortunately, the type of Suter's variety is in a separate tube from other specimens. In his description he remarks on the absence of axial riblets, but failed to note the difference in the spiral sculpture, the keel, and the aperture.

Columbarium maorum n. sp. (Plate 13, fig. 2.)

The only specimen has the anterior canal broken off. Shell small, spire narrowly produced, pagodaform, the last somewhat abruptly contracted at base. Whorls seven or eight, a serrated prominent carina below middle, a small thread immediately above serration, from this to suture above slightly concave and apparently without sculpture, area from carina to suture below narrow and concave, a minute thread margins sutures above and below; on base of last whorl are five spiral cords, diminishing in size anteriorly, minutely granulate, narrower than grooves, the two upper cords distant and strongest, the grooves with one or two minute threads; axial sculpture consists of fine growth-lines, more pronounced on base. Protoconch of about two whorls, smooth and lightly carinated. Aperture imperfect, outer lip angled above middle, parietal wall smooth and lightly callused.

Length of spire, 5 mm.; greatest width, 4·5 mm.

Locality: Greyish sandy clay in cutting on Main Road, Pukeuri.

Type to be presented to Wanganui Museum.

The single specimen is very imperfect, but the species may be recognized by the form of the spire and sculpture.

Antimitra vexilliformis n. sp. (Plate 13, fig. 3.)

Shell small, narrowly biconic, whorls seven, turreted, angle slightly above middle on spire-whorls, between angle and suture above slightly concave; sutures not deep, margined below; aperture and canal equals spire in length. Sculpture—protoconch of about one and a half smooth whorls, apex tilted, the following whorls with rather distant axial riblets, about thirteen on a whorl, feeble towards anterior end of body, and with pronounced gemmules at angle, axials below angle crossed by small spiral cords which form gemmules at points of intersection, there are four on penultimate whorl and about eighteen on the last, of which about six on neck and canal are more slender and closer together; above the angle spirals, if any, are microscopic. Aperture slightly oblique, narrowed and angled above, outer lip sharp, columella almost straight, narrowly callused, and with two low plaits at middle, canal short.

Length, 8 mm.; width, 4 mm.

Locality: Greyish sandy clay in cutting on Main Road, Pukeuri, near Oamaru.

Type to be presented to Wanganui Museum.

In form and sculpture this species is in perfect accord with *Vexillum*, but it lacks the important characters on the columella; it makes some approach to *P. nodosoliratus* Suter. We place this species provisionally in *Antimitra*, one of the many genera created by Iredale; unfortunately, that author mars his otherwise good work by burying generic names in the text and by simply nominating the type without reference to its characteristics.

Triploca waihaoensis n. sp. (Plate 13, fig. 4.)

The single specimen available is very fragmentary, the outer lip imperfect, and the spire missing; sufficient, however, remains to distinguish the species, and it is the first record of the genus in our fauna.

Shell small, last whorl convex at periphery and uniformly curved to anterior end, very slightly projecting at suture, the latter a little impressed not deep. Sculpture consists of small flat-topped spiral riblets and axial growth-lines, the latter in places slightly crenulating the riblets, spiral grooves narrower than riblets, about six or seven between lip and suture above, on body below periphery are four or five much smaller than those above and below (this may be an individual character), about twenty-four spirals in all, those at umbilicial depression small and rounded. Aperture oblique, narrow and somewhat produced at base; columella short, almost straight, reflexed and with three stout oblique plaits, the anterior two nearer together. Impressed area behind columella partly obscured with matrix but does not appear to be a true umbilicus.

Length of last whorl, 7 mm.; width, 5·5 mm.; aperture, greatest oblique length, 6 mm.

Locality: Greensands immediately below the limestone, McCullogh's Bridge, Waihao River.

Type to be presented to Wanganui Museum.

This species is closely allied to *T. ligata* Tate; it appears to differ in the narrower and more oblique aperture, the shorter columella, and larger size; the absence of the spire prevents a complete comparison.

The genus *Triploca* was created by Professor Ralph Tate for the reception of a small *Actaeon*-like shell with three revolving plaits on the columella, type *T. ligata* (*Proc. Roy. Soc. N.S.W.*, 1894, vol. 27, p. 186, pl. 11, fig. 7). M. Cossman reviews *Tornatellaea* (*Triploca*) *ligata* Tate, and states that the species is minutely punctate in the spiral sulci (*Ess. Palaeoconch. Comp.*, 1895, p. 50, pl. 7, fig. 19.) Mr. George F. Harris (*Brit. Mus. Cat. Ter. Moll.*, pt. 1, *Australasia*, 1897, pp. 9–10, pl. 1, figs. 2*a*, 2*b*, protoconch) points out that Tate's species is evidently very variable; that the deep sulcation bordering the suture of the type specimens is occasionally scarcely more prominent than the other spirals; that the latter are not always persistent over the whole of the whorls, one museum specimen showing the body-whorl sulcated over two-thirds of the surface only. From the above it will be noted that for specific determination it is unsafe to attach overmuch importance to the number of spiral sulcations or their disposal.

Tate's species from the Adelaide bore he classified as Eocene. Harris (*op. cit.*), reviewing the Limacinidae and Volutidae from the lower Tertiaries of Australia, is not disposed to assign to them so great an age, remarking that their development is more advanced than one would expect to find in beds as old as the true Eocene. The age of the Waihao greensands is discussed at pp. 116–19 in this volume: there can scarcely be any doubt that they represent the highest beds of the Hampden series.

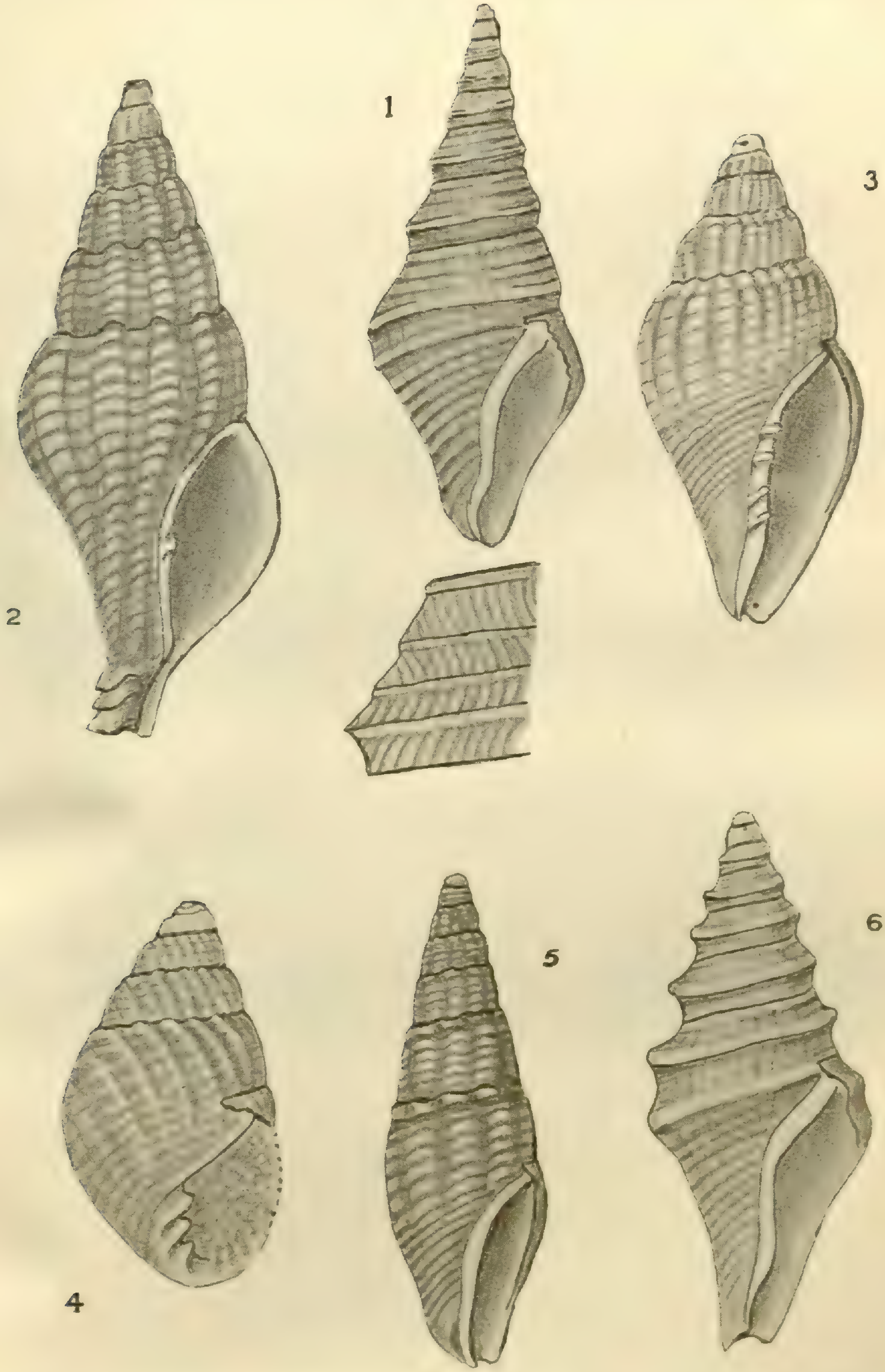


FIG. 1.—*Bathytoma transenna* Sut., and sculpture.
FIG. 2.—*Latirofusus optatus* n. sp.
FIG. 3.—*Vexillum plicatellum* n. sp.
FIG. 4.—*Bonellitia hampdenensis* n. sp.
FIG. 5.—*Drillia apicarinata* n. sp.
FIG. 6.—*Surcula protransenna* n. sp.

Face p. 128.]

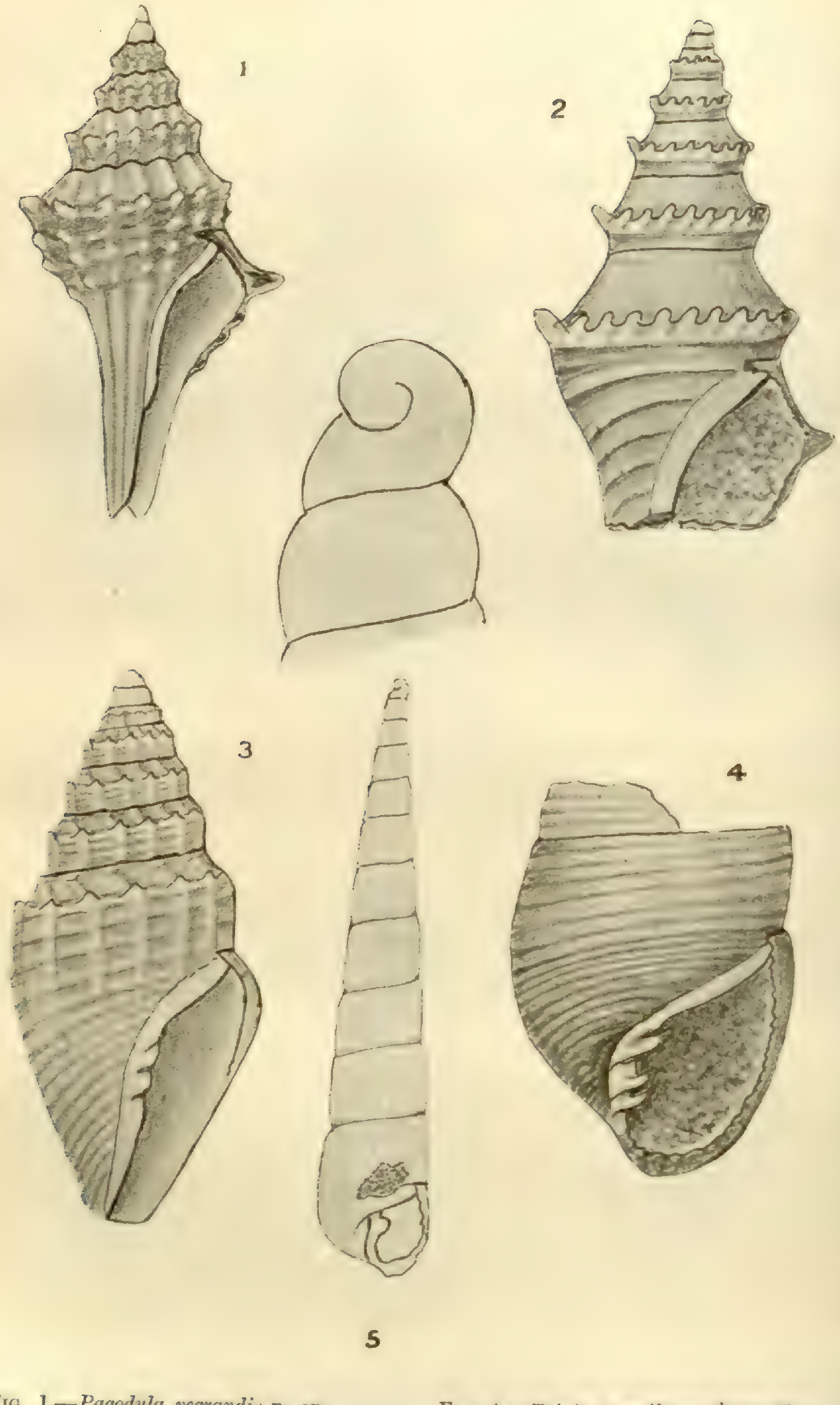
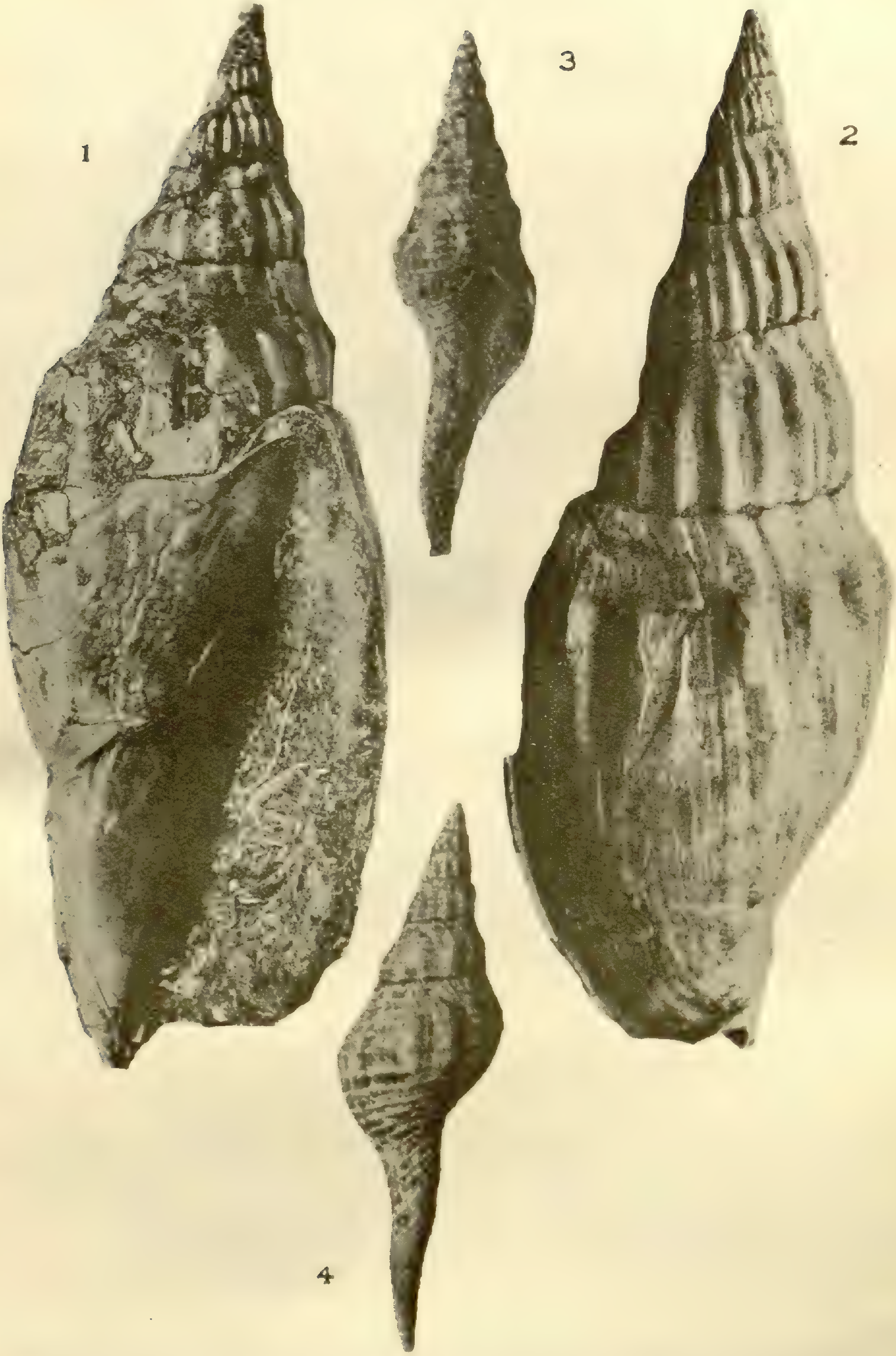


Fig. 1.—*Pagodula vegrandis* n. sp.
Fig. 2.—*Columbarium maorum* n. sp.
Fig. 3.—*Antimitra vexilliformis* n. sp
Fig. 4.—*Triploca waihaoensis* n. sp.
Fig 5.—*Syrnola semiconcava* n. sp. (shell and protoconch).



Figs. 1, 2.—*Fulguraria morgani* (adult).

Figs. 3, 4.—*Verconella delicatula* n. sp.

FIGS. 1–3.—*Fulguraria morgani* (juvenile).
FIGS. 4, 5.—*Austrotriton neozelanica* n. sp.
FIGS. 6, 7.—*Lippistes benhami* Sut. var. *perornatus* n. var.

ART. 11.—*The Occurrence of the Genus* Lahillia *in New Zealand.*

By P. MARSHALL, M.A., D.Sc., F.G.S., F.N.Z.Inst., Hector and Hutton Medallist, and R. MURDOCH.

[*Read before the Wanganui Philosophical Society, 27th October, 1921; received by Editor, 15th December, 1921; issued separately, 8th February, 1923.*]

Plate 16.

LAHILLIA is a genus of pelecypods that has a restricted geographical occurrence as well as a restricted range in geological time. It is therefore a genus of considerable importance, both in regard to former geographical conditions and also in connection with the correlation of geological formations in different countries. Up to the present time *Lahillia* has been recorded only from the Upper Cretaceous and Lower Tertiary formations of South America and Antarctica, where it is of quite frequent occurrence. The record of the occurrence of this genus in New Zealand seems to be of such great importance that we take the opportunity of transcribing remarks that have been made about it by geologists in South America.

Wilckens makes the following remarks about the genus: "Die gattung *Lahillia* die sich in Obersenon von Quiriquina (Chile) und Südpatagoniens und in Tertiar von Patagonien und Chile findet ist auch in Antarctischen Senon vertreten so dass sie als eine für diese ganze Region besonders kennzeichnende Versteinerung betrachtet werden kann." (Otto Wilckens, "Die Anneliden, Bivalven, und Gastropoden der Antarctischen Kreideformation," *Schwed. Südpolar Exped.*, Bd. iii, Lief. 12, Stockholm, 1910.)

Von Ihering, in his work "Les mollusques fossiles du Tertiaire et du Crétacé superieur de l'Argentine" (*Annales del Museo Nacional de Buenos Ayres*, ser. iii, tome vii, p. 83, 1907) makes the following remarks: "Le genre *Lahillia* bien developpé dans les faunes Supracrétacé et Eocene de la Patagonie et du Chili, n'a pas été trouvé dans la Nouvelle-Zélande." This remark is repeated on page 90. On page 499 he says, "Le genre singulier *Lahillia* dont la distribution a été restreinte au Chili et à la Patagonie, se trouve aussi bien dans la Crétacé superieur et dans la patagonien. On voit que les relations faunistiques entre le Crétacé superieur et le patagonien sont les plus intimes possibles, et ce fait pour fixer l'âge Eocene de la formation patagonienne, me parait bien plus important que ne l'est le nombre restreint d'espéces vivantes qui s'y sont trouvées." On page 492 he says, "Un genre specialement caracteristique du Tertiaire chileno-patagonien est *Lahillia*." Further on page, 498, "En général le nombre de genres qui sont caracteristiques pour cette ancienne faune antarctique et qui lui sont exclusifs est tres restreint et presque reduit à *Struthiolaria*, *Malletia*, et *Lahillia*: ce dernier genre ne parait pas avoir atteint la Nouvelle-Zélande."

In 1917 Woods described the Cretaceous faunas of the north-eastern part of the South Island of New Zealand, and amongst the species that are recorded is a doubtful *Mactra* (*N.Z. Geol. Surv. Pal. Bull. No. 4*, p. 30, plate xvi, fig. 8, 1917). In a critical reference to this publication Wilckens makes the following statement: "Diese muschel ist keine *Mactra*, sondern eine vertreterin der für das patagonische und antarctische Obersenon so beseichnenden Gattung *Lahillia* die sich auch in den Quiriquinaschichten

findet und ausserdem in patagonische und antarctische Altertertiar wiederkehrt" (O. Wilckens, *Cen. f. Min.*, &c., Jahrg. 1920, No. 15 *u*, 16, p. 264). The specimen was too imperfect for Woods to write any description of it, but its form in the figure he gives is certainly different from that of the present species.

Lahillia neozelanica n. sp. (Plate 16, figs. 1–3.)

> *Mactra crassa* Marshall *non* Hutton, *Trans. N.Z. Inst.*, vol. 49, pl. xxxvii, fig. 49 (figure only).

Shell of moderate size; height 72 mm., length 78 mm; another specimen, height 37 mm., length (imperfect) 33 mm. Shell thick, rather swollen, umbo curved forward, beak median, posterior margin regularly curved, descending rapidly, the ventral margin gently rounded, anterior margin in front of the beak somewhat concave, descending less rapidly than the posterior, the anterior end broken off. Surface nearly smooth, marked with a large number of concentric lines in larger and smaller series, the latter from six to ten between each pair of the larger lines, on the posterior margin they are sharply raised and closely crowded together. Hinge of right valve with a large, deep, and very marked pit below the beak, slightly oblique and the posterior margin longest, outside of this a narrow groove followed by a long somewhat narrow tooth coalescent above; anterior to the pit the hinge-plate is large, thick, and somewhat curved, with no distinct tooth-like projection; the whole hinge, however, is corroded.

Specimens have been found at Wangaloa only.

Type to be presented to the Wanganui Museum.

The specimen originally figured by Marshall as *Mactra crassa* is not at present available, and the larger measurements given are taken from the figure of that specimen. The above description has been drawn from a smaller right valve (imperfect), and the interior filled with hard matrix, while the hinge is that of a fragment of a much larger right valve with the beak eroded.

This species approaches *Lahillia luisae* Wilckens, from the Upper Senonian of Seymour Island, in sculpture, but is wanting in the subangular separation between the posterior and dorsal margins. It differs from *L. larseni* Wilckens, from the Tertiary of Seymour Island, in form and sculpture. It is higher in proportion to length when compared with specimens from the Upper Senonian of South Patagonia. The hinge and, as far as can be seen, the form, resemble those of *L. veneriformis* Hupé from Quiriquina, but no description of the form or sculpture or of the dimensions of this species are available.

It will be understood from the above that the genus *Lahillia* has previously been restricted, so far as its occurrence is concerned, to the Cretaceous and older Tertiary of Chile, Patagonia, and Seymour Island. Wilckens's reference which has been mentioned above is the only suggestion of its occurrence in New Zealand. Its inclusion in the New Zealand fauna obviously provides further proof of the former connection of New Zealand and South America, through the Antarctic continent, in the Cretaceous and early Tertiary. It is interesting to remember also that this Wangaloa fauna contains species of *Heteroterma* and *Perissolax* which are very closely allied to species from the Tejon fauna of California.

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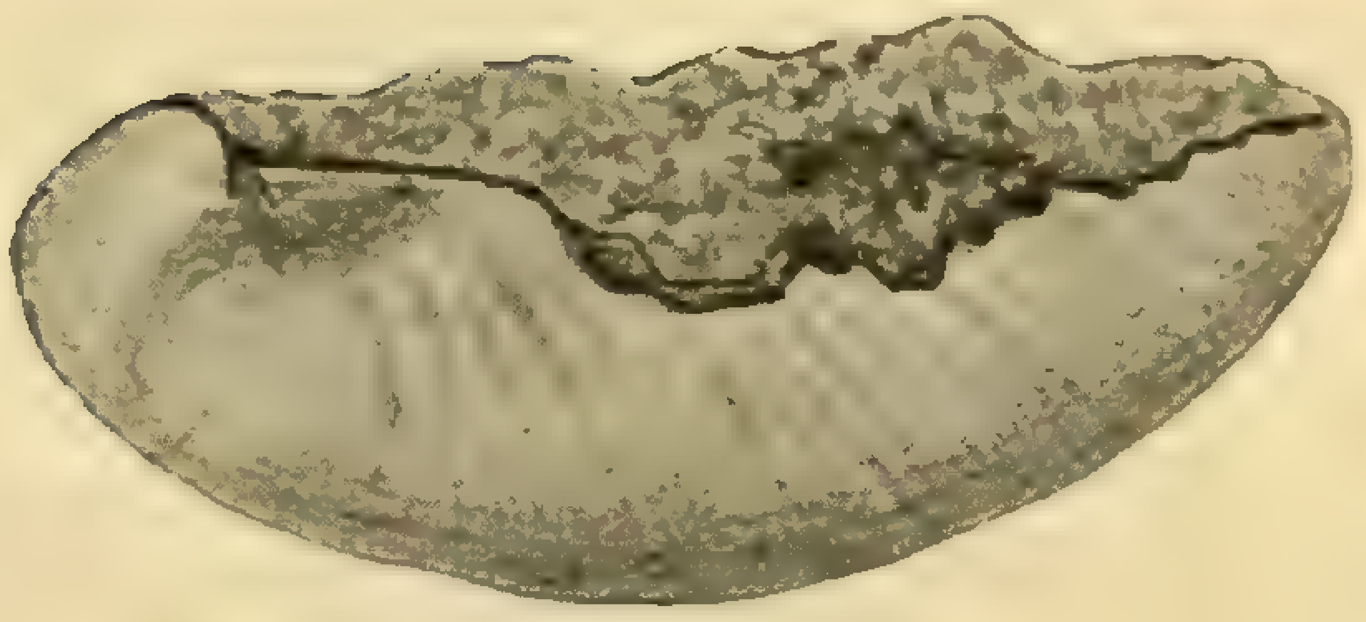

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FIG. 1.—*Lahillia neozelanica* n. sp. Right valve. Height, 37 mm.; length in profile, 33 mm.
FIG. 2.—*Lahillia neozelanica* n. sp. Same specimen. Profile.
FIG. 3.—*Lahillia neozelanica* n. sp. Fragment of a large right valve to illustrate the hinge.

Art. 12.—*The Occurrence of Land Mollusca in a Recent Sea-beach Deposit.*

By R. Murdoch and H. I. Finlay, M.Sc.

[*Read before the Otago Institute, 8th November, 1921; received by Editor, 5th December, 1921; issued separately, 12th February, 1923.*]

Plate 17.

During the early part of this year, one of us (Finlay), when examining the shore-line near the mouth of the Akatoa Creek, made the discovery of a small beach deposit exceedingly rich in land-shells.

Records of our land Mollusca occurring in the Recent rocks are very rare, and the same may be said of their occurrence subfossil; no considerable assembly of species has been found, nor an abundance of any single species. It is therefore of particular interest to find, on the highest margin of the strand, no less than ten species of land Mollusca, including an undescribed species of *Ptychodon.* The majority of the species are in great profusion, and well preserved; and, from the freshness of their colours, give the false impression that they had not been deposited for more than a few months. The bed in which they occur has been in existence for more than thirteen years, and its extent has not noticeably changed during that time.

The Akatoa Creek opens on to the coast some five or six miles south of the Taieri River, and the deposit in which the shells occur is north of this creek some 20 or 30 chains, situated in one of the sinuosities of the coastal line, and backed by low hillocks. The bed occupies the highest margin of the strand, as illustrated (Plate 17, fig. 1). It has a length of about 130 ft. and a greatest thickness of approximately 3 ft., thinning out to the end most distant from the Akatoa Creek. Mr. Agnew, who has occupied the adjoining lands for the past thirteen years, states that the bed was in existence prior to his arrival, that he has made constant use of it for poultry-grit, and that he has not observed any marked differences in its extent during that period. There can be no doubt that the bed has suffered from tides and storms, but, from the fact that it has in a measure survived the storms of perhaps a score of years, its remnant may be regarded as fairly secure against the ravages of the sea.

The bed consists of a coarse quartz sand, a considerable amount of dark loamy earth, and a few stones, the latter with sharp fractures and evidently but little subjected to beach-rolling. In addition to the land-shells, there is a fairly large number of Recent marine species, a list of which is appended; and we have little doubt that further collecting will add to the number of species.

It appears scarcely probable that the land-shells are from the adjoining hillocks: no doubt, in times past, these were scrub-covered, but they are of very limited area. The nature of the bed and the immense number of specimens it contains suggest that the Akatoa Creek is the source from which they were derived. The drainage area of the creek does not extend beyond the coastal hills. Within that area and during recent years the bush has been largely destroyed by fires, and, with the exception of patches of scrub in the numerous small gullies, there is now no native bush of any extent within two or three miles of the coast.

It will be admitted that every stream draining a forest-covered country carries on its waters, especially at times of high flood, some of the animal-life whose habitat is the ground. Almost the whole of our land Mollusca shelter under fallen timber and amongst the leaves and decaying debris. An exceptionally torrential rainfall would scour hillsides and gullies, and carry to the main stream very considerable quantities of loam and debris, together with the animals inhabiting it. We have only to view some of the large rivers, such as the Wanganui when in high flood, to gain a clear conception of the vast toll gathered from the forest lands: its surface is strewn with huge logs, freshly uprooted trees, and masses of debris, the water charged to its maximum carrying-capacity with loam and sandy clay. This continues for hours, and in a lesser degree for several days: on entering the sea it forms a great fan of discoloured water extending to the horizon. In such a flood immense numbers of the land-snails must have shared the fate of not a few of the higher animals, yet they leave little record on the beach. A careful search may reward the collector with a few specimens only.

Almost the whole of our land-shells are very fragile, and no doubt the pounding they receive in the surf is sufficient to destroy them. This, however, does not appear to be the sole cause of their non-preservation: there are large streams flowing into well-sheltered bays and harbours, and each deposits its quota of land-shells in the protected waters. During Tertiary and Cretaceous periods, we may reasonably assume, innumerable similarly situated streams must have existed, but, so far, little record of the land molluscan fauna has been found in the rocks. The shells as a whole are constructed of a very thin calcareous deposit, and when the epidermal conchin is destroyed they are in a condition readily to disintegrate. A brief period of immersion in water is sufficient with most of our species to destroy the epidermal coating.

The conditions that obtained when the Akatoa bed was deposited must have been unusually favourable. Its position above the high-tide level would appear to indicate a strong banking of the sea on the coast, that it held the storm-water and silt from the land close on the shore-line, and that it was not subjected to a heavy surf. No doubt the bed extended considerably along the shore and only a fragment is preserved.

We are informed by a resident who occupies land several miles nearer to the Taieri River that a similar bed occurs on the coast opposite to his farm. We have had no opportunity of examining the deposit, and it may or may not be of a similar nature. Should it, however, prove to contain a land fauna, then its source is more than likely to be the Taieri River. The fact that this is the first record of a land fauna in a sea-beach deposit goes far to prove that they must be of rare occurrence, and it is much to be desired that a careful investigation of the coast-line be made between the Taieri River and the Akatoa Creek.

List of Land Mollusca.

Aeschrodomus barbatula (Reeve)
Allodiscus planulatus (Hutt.)
Charopa (“*Cavellia*”) *biconcava* var. *minor* Sut.
Charopa (“*Fectola*”) *otagoensis* Sut.
Charopa (“*Fectola*”) *tapirina* (Hutt.)
Phrixgnathus celia Hutt.
Phrixgnathus pumila (Hutt.)
Ptychodon suteri Murdoch and Finlay.
Thalassohelix igniflua (Reeve)
Therasia thaisa Hutt.

Fig. 1.—Near view of part of shell-bed near mouth of Akatoa Creek.

Fig. 2.—*Ptychodon suteri* n. sp. × 9.

LIST OF RECENT MARINE SPECIES ASSOCIATED WITH THE LAND MOLLUSCA.

Argobuccinum tumidum (Dkr.)
Amphidesma subtriangulata Wood
Cardita calyculata (L.)
Chione stuchburyi Gray
Chlamys dichrous (Sut.)
Gadinea conica Angas
Gibbula nitida Ad. & Ang.
Haliotis iris Mart.
Lasaea neozelanica Sut.
Mactra discors Gray
Melarhaphe unifasciata Gray
Melarhaphe cincta Q. & G.
Modiolus neozelanicus Iredale
Monodonta aethiops Gmelin
Mytilus canaliculus Mart.
Mytilus edulis L.
Mytilus maorianus Iredale
Neothais lacunosa (Brug.)
Notoaemaea parviconoidea (Sut.)
Notoaemaea pileopsis (Q. & G.)
Odostomia vestalis Murdoch
Ostrea tatei Sut.
Patelloida stella var. *corticata* (Hutt.)
Plaxiphora coelata Reeve
Protothaca crassicosta (Desh.)
Risellopsis varia Hutt.
Risellopsis varia var. *carinata* Kest.
Sigapatella novaezelandiae (Less.)
Spisula aequilateralis (Desh.)
Trichotropis inornata (Hutt.)
Trophon patens (H. & J.)
Trophon squamatus (Hutt.)
Turbo smaragdus (Mart.)
Turritella rosea Q. & G.
Umbonium anguliferum (Phil.)
Venerupis siliqua Desh.
Verticipronus mytilus Hedley.
Xymene plebejus (Hutt.)

Ptychodon suteri n. sp. (Plate 17, figs. 2, *a*, *b*, *c*.)

Shell minute, spire slightly domed, subdiscoidal, sutures deep, umbilicus wide, equal to one-third of the greatest diameter. Colour pale to dark horny with broad bands of rufous, always more marked on dorsal surface and frequently having a tessellated appearance, irregular streaks on the periphery, bands almost absent on base. Whorls 5½ to 6, protoconch of about 1½ whorls, smooth, somewhat shining, the initial coil wider than the succeeding which is very narrow, thence very slowly increasing, rising abruptly from the sutures, the last lightly convex on periphery, rounded on base. Sculpture consisting of radial fine riblets, directed slightly forward above, slightly flexuous on periphery, and straight on base; about 16 to 18 per millimetre, narrower than interspaces, the latter with microscopic growth-lines and more feeble spirals; occasionally on margin of umbilicus a number of faint spirals. Aperture oblique, lunate, armature exceedingly variable, usually 1 small lamella rather above middle on outer lip and 2 lamellae near lower margin of lip, these are frequently indicated externally by opaque lines; in some examples 1 to 6 feeble lamellae on parietal wall, or a roughened callus only, or smooth; outer lip occasionally with 2 distinct lamellae about middle, or several indistinct threads, at base of lip occasionally a serrated tooth and 1 lamella, in many examples they are deep-seated and very obscure. Umbilicus perspective, showing apex and sides of all the whorls.

Height, 1·25 mm.; width, 2·50 mm.

Type, and many paratypes, in Mr. Finlay's collection. Co-types presented to the Wanganui Museum and to the Otago University Museum.

There are numerous examples of the species. Usually the position and number of lamellae in the aperture of other of our species are constant characters; in this the colour-pattern, together with the number of riblets and the proportional width of the umbilicus, will prove the best guide.

Art. 13.—*Water-conservation and Hawke's Bay Artesian Systems.*

By H. Hill.

[*Read before the Hawke's Bay Philosophical Institute, 26th November, 1920 ; received by Editor, 24th November, 1921 ; issued separately, 12th February, 1923.*]

On frequent occasions I have had the honour of bringing under the notice of the Philosophical Society the question of artesian wells and systems of wells.* Not merely in Napier and over the Heretaunga Plain as far as Pakipaki are flowing wells to be seen, but also at Otane, at Ongaonga (on the Ruataniwha Plain), at Wanganui, at Palmerston North, at Poverty Bay, and other places.

As settlement and population increase, so also do regulations multiply affecting the rights and duties of citizens. Water being one of man's essential wants, the duty of every local and governing authority is to pay heed to providing a suitable supply of potable or drinkable water ; and, if a manufacturing community, also water suitable for the fostering of manufactures.

Since my first paper on the artesian-wells system of the Heretaunga Plains the town of Napier has increased in its population to a fair extent, and perhaps the settlement of population over the plain has increased even to a larger extent. In the year 1887 Napier was supplied with water by means of six artesian wells, four of them having a 3 in. bore and two a 2 in. In July, 1917, a return was presented to the order of the Borough Council giving a list of nineteen wells supplying water for public use—two wells of 6 in. bore, two wells of 4 in., and seven of 3 in. These wells were returned as varying in flow from 20 to 10,000 gallons per hour. In this return the best flowing wells are given as being situated in Nelson Park, in Sale Street, and at the junction of Munro Street with Raffles Street. The total flow from the nineteen wells was said to be 1,730,100 gallons per day, weighing nearly 8,000 tons. Since the return was made a number of other wells have been driven to the order of the Council. Up to the end of January, 1919, new bores added more than half a million additional gallons to the borough supply. Thus, assuming that no falling-off in the quantity of water from the wells as returned in July, 1917, has taken place, the daily supply of water to the Napier Borough should be 2,210,000 gallons. If the present population of Napier is 15,000 (an over-estimate) the supply represents more than 145 gallons of water daily for every man, woman, and child in the town.

The number of artesian flowing wells that are supplying the water requirements at Taradale, Meeanee, Farndon, Clive, Awatoto, Hastings, Mangateretere, Havelock, and Pakipaki must be very great. In the year 1887, at the time when six wells sufficed for the Napier Borough supply, it was estimated that not fewer than three hundred wells were to be found over the whole of the plain area outside Napier. Thus in the Borough

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* See *Trans. N.Z. Inst.*, vol. 20, pp. 282–93, 1888 ; vol. 22, pp. 429–38, 1890 ; vol. 37, pp. 431–44, 1905.

of Hastings, where no local scheme of supply then existed, more than ninety wells were known to be in use, and on the lands owned at that time by Messrs. J. H. Coleman, J. D. Ormond, J. N. Williams, and T. Tanner there were more than fifty wells. Assuming the number of artesian wells put down in the Heretaunga area has merely increased in the same proportion as those in Napier during the interval, then the number of wells over the plain and in various towns and townships would exceed 1,100. I do not think this estimate in any way excessive. There is, however, a difference in the diameter of the wells put down. For domestic use the wells are usually a 2 in. bore, and for manufacturing requirements a 3 in. bore, the exception being the riverside well at Farndon, where there is a 6 in. bore for wool-scouring purposes. Taking the wells throughout the plain area

MAP OF HAWKE'S BAY DISTRICT, SHOWING ARTESIAN-WELL AREA (RUATANIWHA, HERETAUNGA, AHURIRI, AND TE AUTE PLAINS).

Black circles show artesian wells. Artesian area shaded.

as averaging a 2 in. bore, and that the flow of the wells is proportionate to the flow in the Napier wells, then, if a 4 in. bore gives a flow of 6,000 gallons per hour, a 2 in. well under similar conditions will give 1,500 gallons an hour. Hence 1,100 wells flowing at the rate of 1,500 gallons an hour for each will every day yield 29,600,000 gallons. The annual yield, if spread over the surface, would represent an annual rainfall of 7 in. over the 80,000 acres of plain.

According to the analysis of the water from nineteen different wells, it is shown that in every 100,000 gallons of water there are 20 gallons of

solids held in solution. In the Napier wells, and estimated on the flow already stated, there are 440 gallons daily of solids brought to the surface, or 951 cubic yards in a year. So also on the same proportionate estimate of solid contents in the supposed 1,100 wells over the plain area, 17,130 cubic yards of solids are brought to the surface in solution in the course of the year.

The general purity of the water as determined for Napier is in every respect satisfactory. It would be well, however, to have its actual hardness determined. The receiving tanks or basins into which the water flows from the different wells tell their own story as to the sand, shingle, and other material that is brought to the surface, and unless there is replacement of the material that is withdrawn with the water in suspension and solution the overlying pressures will in time bring about altered conditions in the water-bearing beds. Creeps are certain to occur. They may at the present time be hardly appreciable, but experience can be quoted of important changes taking place in various wells both in Napier and the plain area, and I do not doubt, if only proper records were kept, some surprising results would be available.

The facts that have been obtained as to the varying depths of the artesian wells in different localities enable a section to be drawn showing the deepest line of water-supply over the plain, and so also showing where the valley shallows and the wells diminish in depth. A knowledge of the facts is necessary to the proper determination of the water-flow that is of so much value to the community.

The surface of the plain itself presents some surprising and interesting features, and especially so when considered in relation to the depth of the wells. The plain at Roy's Hill, on the left of the Hastings–Maraekakaho Road and opposite the junction road to Fernhill, is 166 ft. above sea-level, and is almost south-west of Scinde Island. Taking this as the highest point of the plain, the following heights are of interest. The height of Omahu, at the bridge across the Ngaruroro River, is 73 ft., and at the old mill on the Redcliffe Road it is 45 ft. At the Tutaekuri River bridge, Redcliffe, it is 34 ft., and at Taradale, at the junction of the roads near the post-office, it is 16 ft. At Pakipaki it is 32 ft., and midway between Hastings and Pakipaki it is 41 ft. At Havelock, at the bridge on the Hastings Road, it is 34 ft., and at Hastings, at the railway-crossing, 41 ft. At the junction of the Napier–Havelock and Napier–Hastings Road at Mangateretere it is 15 ft., at Pakowhai 18 ft , and at Meeanee 9 ft. These heights show the gradual slope of the plain, and it is possible to follow the old river-valleys as the rivers meandered over a swampy surface that every flood modified and increased. Few wells other than those in the Havelock Township are situated on the plain at a higher elevation than 40 ft. to 45 ft. In putting down a bore on higher land the water in the tube may rise to a level representing 40 ft. or a little more above sea-level, but no flowing wells are obtained on the plain area higher than this. Some years ago Mr. R. D. McLean put down a trial bore in the vicinity of his Maraekakaho property, but no flow was obtainable. I believe, however, that water rose in the pipe corresponding to the height of the water-table, as in the case of the artesian wells. It is interesting to note the altering depth of the wells between Pakipaki and Napier—the line representing the deepest portion of the old valley, or, in other words, the trough. At Pakipaki, towards Pukahu, the wells vary from 70 ft. to 100 ft., and to 125 ft. towards Longlands. These places are about 40 ft. above sea-level, so that the water

is found from 40 ft. to 50 ft. below sea-level at Pakipaki, somewhat deeper at Pukahu, and 25 ft. or more still deeper at Longlands. Hastings has an excellent well that is 230 ft. below sea-level, and in Napier there is a well that is 397 ft. below sea-level, the water from which flows 26 ft. above the surface.

These facts show the general depth of the water-bearing beds in different parts of the plain, but, unfortunately, no scientific work has yet been done in the way of mapping the water-bearing area, because it is only in exceptional cases that a trial bore is put down to test a deeper area for a fresh water-bearing bed. It would be folly to assert that another water-bearing bed is not possible in certain places over the plain. In Napier a trial bore went down some years ago to the depth of 743 ft., and the river-alluvial had gone. So also at Greenmeadows the late Mr. H. Tiffen put down a trial bore to a depth of 600 ft., but after the first 100 ft. the pipe went into the blue fossiliferous clays that are exposed in the district underlying the limestones, and there was no water-result. But when more consideration is given to the conservation of water the number of water-bearing beds will be known throughout the plain area, and it will be possible to discover any alterations that are taking place in the closing or blocking of beds, and it may possibly come about that the actual sources of supply will be found, which at present are mere matters of surmise.

For many years this question of artesian water-supply has been studied by me, and records have been kept in the expectation that the time will come when the facts that have accumulated will lead public bodies to unite in the utilization and scientific development of their water-supplies. At the present time each district provides in its own way for its own requirements. Napier, Taradale, and most of the plain area are entirely dependent on an artesian water-supply. Hastings, however, and, I believe, Havelock, have each a gravitation supply. Much attention has been given in the United States to the scientific study of artesian wells and to the causes leading to their exhaustion, which has occurred in various districts. The following quotation is taken from the United States Geological Survey water-supply and irrigation papers :—

"It must be kept in mind that there is a limit to the amount of water that can be withdrawn from an artesian basin. There is no such thing as an inexhaustible supply in this connection. The amount of water available is limited, on the one hand, by the amount of rainfall upon the catchment area and the facility with which the rainfall can obtain entrance to the porous stratum, and, on the other hand, by the capacity of the water-bearing rock to transmit the water over long distances and the diminution through leakage and seepage. These two limiting conditions are usually of sufficient magnitude to render the overdrawing of the supply a practical and present danger which should be constantly kept in mind." These are words of wisdom, and are based on an experience which has not yet occurred in this Dominion, though there are many symptoms of a diminishing pressure in a number of wells both in Napier and over the plain. In scores of instances it is found that the head or water pressure in a water-bearing area is constantly lowering where large quantities of water are being borne away. Underground supplies are limited as to quantity of water available, just as a river is limited by the supply of its tributaries.

There is now and then an apparent clogging of the water-bearing rock in the immediate neighbourhood of the well. Whether the clogging

is due to the deposit of fine silt in the pores of the rock, or to a microscopic growth of plant-life, or to a gelatinous deposit of iron, has not been determined; but the withdrawal of solids in solution and suspension in the water is sufficient cause to account for a large diminution of flow in a given area, even though the quantity of water has not apparently diminished. The putting-down of a large number of wells naturally leaves spaces where formerly was a water-channel full of water. The spaces increase as every bore is driven into the water-basin. A well put down in Munro Street between May and August, 1888, was said to have struck water at 183 ft. The well was a 6 in. bore, and large lumps of clay were thrown up, and soon the well brought to the surface nothing except blue sand in a discoloured water. In the course of a day or two the street in the vicinity of the well was covered with sand. The cause being discovered, the pipe was driven to a depth of 196 ft., when the sand ceased. More than 110 loads of sand were carted away from about the well, and certainly it did not represent one-half the quantity brought up. It can be understood what the effect the withdrawal of so much sand must have upon the adjacent overlying beds. The pressure would in the course of time bring about creeps, and the well, which cost nearly £300 to put down, was soon after abandoned, it having become choked.

In addition to the wells put down in Napier under the direction of the borough authorities, others have been undertaken by private persons or companies. Some years ago the borough authorities had a well driven to a depth of 743 ft., and Robjohns and Co. went down 753 ft. in the hope of striking water, but both were unsuccessful. The deepest flowing well in Napier is 404 ft. The flow is excellent, and when water was struck it rose 26 ft. or more above the surface. In this same well a water-bed was passed at 240 ft., and another at 337 ft. There is a good flowing well at the gasworks, the depth being 229 ft. The wells that make up the borough supply are scattered irregularly over the flat area, but the present system causes great loss in the flowage of water from the different wells, on account of imperfect reticulation. The wells put down along Munro Street indicate the general dip of the underlying beds, and act as a guide to the tilt of the water-bearing bed in the vicinity of Napier. Thus, in Munro Street, 24 chains from the foot of the hills is a well 166 ft. deep; 14 chains farther along the street is another well, 196 ft. deep; and 20 chains farther along, near the junction of Munro Street with Hastings Street, is another, 240 ft. deep. This gives a deepening in the water-bed of something like 2½ ft. in every chain along the street towards the south by east, and no doubt the deepest wells will be found near the railway at the corner of George's Drive.

The wells put down in Nelson Park, and subsequently in McLean Park, appear to have seriously interfered with the flow of the smaller private wells in the immediate neighbourhood, and some of the latter have even ceased to flow. This is sufficient evidence pointing to the limitation in the underground supply-beds, and the authorities would be acting wisely by adopting some means of testing the variation of flow in three or four of the best flowing wells. There is no cause for alarm as to the water-supply being insufficient for public requirements, but it is only by carefully recording changes in supply, particularly during or following years of rain-shortage, that a proper estimate can be made as to whether it is advisable to regulate the flow of wells during a portion of the year.

The well owned by the South British Insurance Company to the left of the road after crossing the Tutaekuri bridge on the Taradale Road was put down in 1891 by Mr. Gilberd. It is 133 ft. deep. To the west and south-west of Napier South, in the direction of Greenmeadows and Taradale, the wells die out as the hills are approached. In the year 1890 the late Mr. Tiffen had a well put down near where Mr. Hindmarsh resides at Greenmeadows, to a depth exceeding 600 ft., but without success.

The wells in that district vary in depth from 80 ft. to 115 ft. according to position, shallowing towards the hills. The Taradale wells vary from 50 ft. to 95 ft., although Mr. Halpin reports a 2 in. well put down twenty-five years ago to a depth of 125 ft. with a flow of 4,000 gallons per hour. This suggests the existence of a second water-bearing bed. At the Park racecourse there is a well 135 ft. deep; in Avenue Road the Roman Catholic Seminary supply-well is 110 ft.; and at the police-station the well is 100 ft. In the direction of Jervoiston and Meeanee the wells deepen somewhat. Mr. T. B. Harding, of Jervoiston, reports having a well 92 ft. deep, put down in 1901; but Messrs. Harris, Lynch, and Alvine report wells varying from 150 ft. to 160 ft. Mr. English has a well 180 ft., Mr. P. Parsons one 185 ft., and the Rev. Father Hickson reports one 240 ft. deep, all in the Meeanee district. The latter well is said to have been put down in 1862, but this is clearly a mistake, as the first well put down in Hawke's Bay was carried out by Messrs. Bennett and Lord, who arrived in Hawke's Bay from Christchurch in the year 1866; the depth was 170 ft. The late Mr. George Rymer sent me a letter he had received from Mr. Lord, written from Normanby on the 4th October, 1916, the gist of which is that he and Bennett put down a well in Peacock's paddock in November, 1866, which was a failure. Then a trial was made in Davis's paddock in January, 1867, when water was struck at a depth of 145 ft. They then went to the Mission Station and got water at 175 ft. This also was in January, 1867. The well put down in Napier was on the site of Swan's Brewery, the depth being 212 ft., and the flow very good. I give these three wells prominence because of their historical value.

The deepest well in Hastings is Newbiggin's. Put down in 1895, three separate flows were found—namely, at 115 ft.; at 198 ft., whence the flow was equal to that at 115 ft., but the water was much harder; and at 271 ft., when an excellent flow was obtained amounting to 30 gallons per minute. In 1904 the Hastings Borough Council put down a bore to a depth of 607 ft., but without success. Quicksand was encountered at 560 ft. In the Clive Grange and Mangateretere districts the wells vary widely in depth, there being two or more beds yielding good flows of water.

Quite a number of wells reach 200 ft.; but Mr. J. Bridgman had a well put down in 1912 to the depth of 153 ft. In the year 1904 Mr. John Davidson had a 2 in. well put down to a depth of 130 ft. from which there was a daily flow exceeding 44,000 gallons. The 6 in. well already referred to, at Riverside, between Farndon and Mangateretere, was put down by Mr. Leipst in 1891. It gives more than half a million gallons a day. The cost of sinking was £47, the well being 147 ft. in depth. The Havelock wells are much deeper than the wells scattered over the plain, and are apparently from a different source of supply. Information as to the character of the water would be of much value. Quantitive and qualitative analysis in the case of a public water-supply should be made

mandatory, and the Havelock authorities would be doing a public service by requiring the Health Officer for the district to test the character of the waters flowing from the wells in the district. This question of the quality of water for household purposes receives little or no attention from the proper authorities, and it is only in times of public danger that the matter of the purity of the water-supply is considered worthy of attention. I think the Public Analyst of each health district should ask for specimens of water here and there, as representing the general supply throughout the several centres of population, and the results should be published with as much regularity by the health authorities as is done in other matters connected with the general health of the community. The well in Havelock near the hotel, at the junction of the five roads, was put down in March, 1892. It has a depth of 325 ft., and when inquiry was last made by me it had a flow of 160 gallons a minute. The well on the late Canon St. Hill's property was put down in June, 1894. The bore is 3 in., the depth 335 ft., and the water rose above the surface between 30 ft. and 35 ft. Mr. M. Hardy's well on the Napier-Pakipaki Road, opposite the Presbyterian Church, was put down in 1893 bv Mr. Gilberd. The depth is 403 ft., and the flow of water amounts to 25 gallons per minute. There are numerous other wells in the locality, but all the facts show that the source of supply is not the same as for the wells out in the plain, unless it is that the second and third supply-beds of the plain have been tapped, the first bed supplying water on the plain dying out in the direction of Havelock, Te Mata, &c. Reference will be made later on to the origin of the water-supply and to correspondence bearing on the question.

Proceeding through Pukehou and Pakipaki, the wells farther to the west and west by south begin to shallow as the latter place is reached, and the whole district, including the freezing-works of Messrs. Borthwick and Co., represents a shallow water-bearing area. I made a special visit to the Pakipaki district in April, 1916, following an unusually dry summer. Many wells were visited, and much information of public interest and value was gathered. Mr. Moroney, a long-time resident of the district, had two wells on his place, one 85 ft. and the other 90 ft. Both of them ceased for a time as flowing wells during the very dry weather of the dry summer of 1914–15, but they recommenced to flow soon after the first heavy rains. Mr. Humphries, another resident, said that his well, which was 80 ft. deep, ran dry in December of 1914, and he had his tap lowered 18 in., but following the early autumn rains the flow returned to normal. Under ordinary circumstances he found a general difference between the height of the summer and winter flow of about 3 in. Mr. Brooker, whose house is situated on the Te Aute – Havelock Road, had three wells, of a depth of 84 ft., 84 ft., and 90 ft. respectively. The flow from one of the wells rose at the time of my visit 8 ft. above the surface-level. During the course of conversation I was interested to note a similar remark from each of the gentlemen named as to the effect of the long period of dry weather on the flow, and the supposed cause. Each one remarked that when the Poukawa Lake went down, the wells perceptibly diminished their flow, especially during the daytime. The information supplied concerning the wells at Messrs. Borthwick and Sons' freezing-works, as to the effect of the dry summer on the daily supply, is of great interest and suggestiveness. The wells are within a mile or so of the Pakipaki Railway-station, and the depth varies from 90 ft. to 100 ft. according to

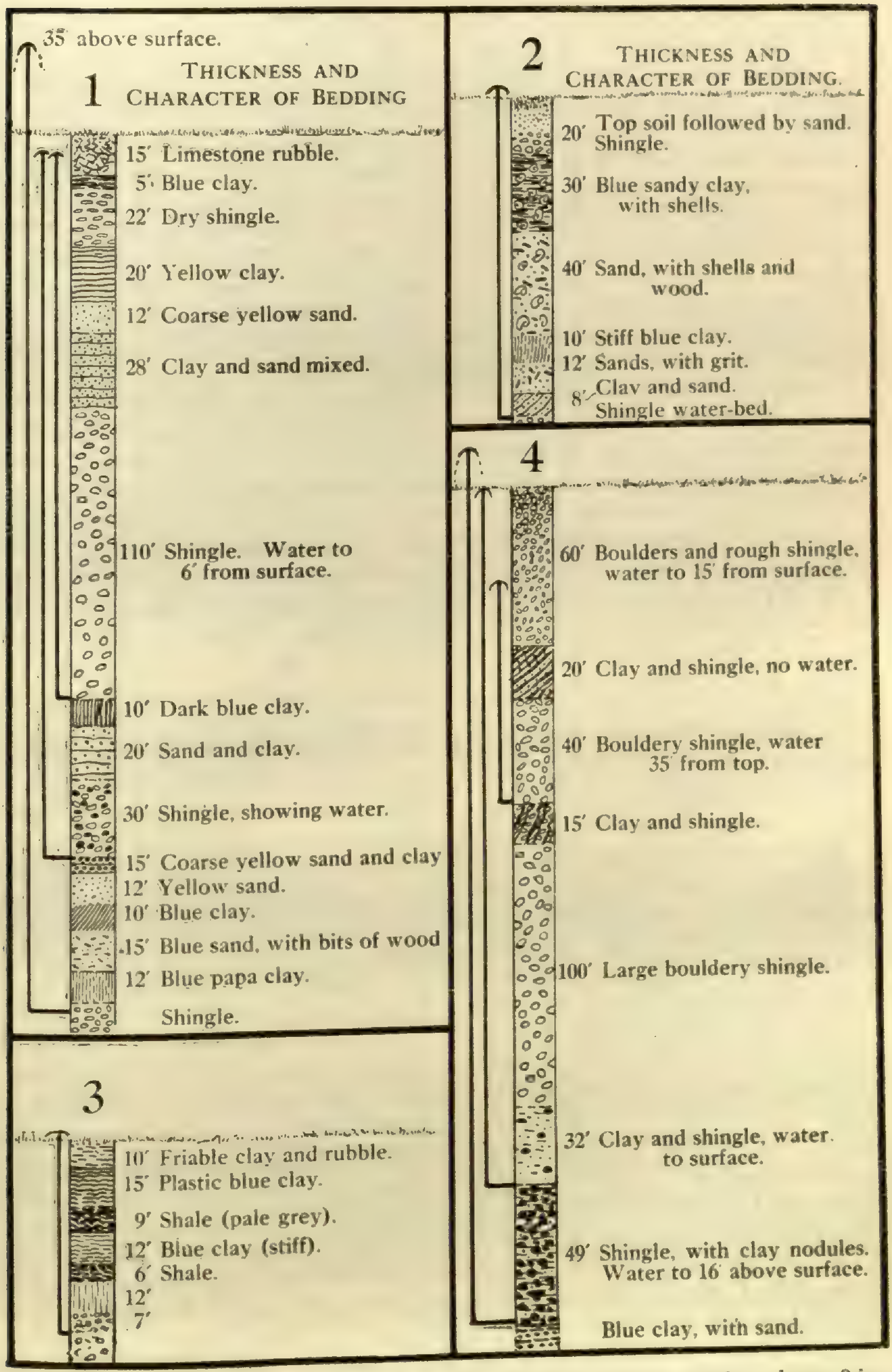

FIG. 1.—St. Hill's well, Havelock North. Mr. Leipst. Depth, 335ft.; bore, 3 in.; flow, 60 gallons per minute. Rises 35 ft. above surface.

FIG. 2.—Riverside well, Farndon, Clive. Mr. Gilberd, December, 1891. Depth, 121 ft.; flow, half a million gallons a day.

FIG. 3.—Otane well, Te Aute. Mr. Leipst, December, 1914. Depth, 71 ft.; bore, 2 in.; flow, 15 gallons per minute.

FIG. 4.—Ruataniwha Plain, well near Ongaonga. Mr. Gilberd, 3rd September, 1892. Depth, 316 ft.; bore, 2 in.; flow, 24,000 gallons daily.

locality. Quite a number of wells have been put down to supply the heavy demands at the works and in the paddocks. The older wells, my informant stated, have altered considerably. They alter immediately after rain. During last season some of the wells ceased to flow. A good shower of rain starts dry wells, and increases the flow of others. All wells are down from 90 ft. to 100 ft. Mr. J. C. Crawley, of Longlands, situated between Pakipaki and Havelock North, stated, "The flow alters in dry weather and immediately after rain." Mr. Buick, of the same district, reported having two wells, and that, following rain, a change is noticeable in the flow in about two days. Mr. C. Livingstone, another settler in the same district, reported having three wells, and that as the rivers increase in volume the wells flow stronger, reaching maximum strength when the Te Aute Lake is at its highest.

Thus all owners of wells in the Pakipaki and Longlands districts report a diminished flow in summer and an increase of flow following rains. In some of the returns from owners of wells reference is made to the occasional deposit of sand, and in several instances to the appearance of small crustaceans in the water. In most of the older wells a diminution of flow is remarked. In the Meeanee district a well throws up sand at intervals, and a little sulphuretted hydrogen is given off from water of wells that have been turned off for any length of time. Following the flow of water in a new well in Munro Street, Napier, it was noticed that if a piece of sacking was placed on the top of the pipe and hit smartly with a mallet the water for a minute afterwards was of milky whiteness.

In two cases reference was made to the effect of high and low tide on the flow, one well being near the shore, the other at Havelock. The lack of regular observation and the general intensity of flow seaward may account for the absence of information in this direction.

In the case of a diminution of flow following a period of dry weather and of a return to normal conditions following rain, more facts would be welcome, especially in the case of wells extending from Napier to Clive Grange and in the Greenmeadows and Taradale districts.

The dry weather naturally lessens the quantity of water flowing from a well during long periods of drought, but it does not follow that a fall of $\frac{1}{2}$ in. of rain could by any manner of means have the result of increasing the flow as the outcome of percolation into the beds. Half an inch of rainfall, following a long season of dry weather, will not affect the subsoil to a depth of 12 in. however porous the beds, nor could it possibly be supposed that 1 in. of rainfall would so affect Poukawa Lake as to produce a marked increase in the flow. There can be no reason to doubt the statement made by so many observers that following a rainfall of $\frac{1}{2}$ in., or of 1 in., or even 2 in., the water shows an increase of flow, but I think it must be set down to the fact that the weight—the increased weight on the surface of the land by the fall of rain—is such that it causes, as in the case of the high tide, an increased squeezing of the porous beds.

It is likely that each river flowing across the plain does a share in supplying water to the underlying beds, but not by surface soakage. Water falling as rain on a definite area does not remain on that area unless retained in a basin; and soakage into beds can ensue at the outcrop of beds only. It is inconceivable for rain-water to soak through 100 ft. or more of rock made up of a variety of strata, some impervious even to the passage of water. If we can imagine a score or more leaves of a book so placed one

above the other that the edge of each leaf is separate from the overlying edge of a leaf by, say, ½ in. or more, the difficulty of water poured along the edges of the leaves passing very slowly underneath each leaf disappears. As soon as the leaves are wetted the passage of water is very slow, and a long time will ensue for water to pass the full length of each leaf with the varying pressures and the air difficulties to be overcome.

But this is what occurs in beds of rock of different materials. Water may pass across the edges of a score of beds of strata on its way from mountain to sea, but the quantity of water that passes into the beds varies according to the porosity of each bed ; and the movement of the water in a bed must of necessity be very slow, by reason of the weight of the overlying pressures. It is in this way that underlying beds as they rest against other rocks at their outcrop receive water-supplies from adjacent beds where springs occur at their outcrop. In other words, the outcrop of some beds where springs occur may lie adjacent to other beds which are totally different in material and situation, and which are so porous as to receive most of the waters flowing from springs connected with an entirely different system of rocks.

As for Poukawa Lake being the source of supply for the artesian waters of the Heretaunga Plain, it may be of interest to explain the relationship existing between the lake and the plain. Hawke's Bay, extending from Portland Island on the north to Cape Kidnappers towards the south, is a part of a land area that was destroyed in part and was otherwise fractured at a period of great volcanic and earthquake activity at the close of the Pliocene and opening of the Pleistocene periods of geological history. The great break about Waipukurau with the Hatuma Lake, and the line of fracture through Otane and Opapa with the series of lakes formed, according to Maori tradition, by Tara and his dogs, represent the result of the devastation and changes brought about at that time. Since then the earth-building has gone on apace. Only Hatuma Lake remains, representing a much larger lake, and the valley between the ranges of hills extending from Waipawa to Napier has been mostly filled by the washing from the rivers and hills that have taken place. The creek from Poukawa into the plain represents what was at one time a much larger communication, and there can be no doubt that water from the lake percolates into the artesian water-bearing beds long before they come within the direct limits of the plain. But what is said of Poukawa applies equally to other valleys that carry waters to the sea across the plain ; hence it follows that there is percolation going on from the Tutaekuri, Ngaruroro, and the Tukituki Rivers long before they enter the limits of the plain, and these sources of supply slowly provide water that is able to give a regular quantity of artesian water, sufficient, apparently, to meet the full requirements of the district, and equivalent, according to my estimate, to an annual rainfall of 7 in. over the entire area of 80,000 acres.

Geologically the Heretaunga Plain is connected with the valley extending from Pakipaki through Opapa, Otane, and Hatuma on to the Ruataniwha Plain, and the following information of wells has been supplied to me by the parties directly concerned.

Otane.—Towards the end of the year 1914 Mr. Leipst was engaged in putting down a number of wells for Mr. R. H. Tod, of Brae Mead Farm, Otane. The wells are comparatively shallow, the deepest being 71 ft., and the others varying from 63 ft. to 40 ft., the latter being the shallowest put down. The flow varies somewhat in amount, the greatest being at the

rate of 15 gallons per minute. The water is of good quality, but no analysis has been made so far as I am aware.

There is no shingle in these wells, the beds in the deepest being 10 ft. friable clay, 15 ft. soft blue clay, 9 ft. shale, 12 ft. greyish-blue clay, 6 ft. shale, 12 ft. blue clay, and 7 ft. shale, in which bed water was obtained (fig. 3).

The wells are in the vicinity of an open well where moa-bones were found during the progress of sinking some years previously. This is evidence to show that the valley-beds have been filled in within the moa period, and followed, or was contemporaneous with, the volcanic and earthquake period which modified the surface-features of the North Island and profoundly affected the whole of the east-coast country. The swamp in the same valley some years ago was found to contain cartloads of unimpaired moa and other bones (*vide* Hamilton, *Trans. N.Z. Inst.*, vol. 21, p. 311, 1889). It is likely that the great basin in which is situated the Hatuma Lake, beyond Waipukurau, with shingle accumulations in various parts, will supply an abundance of water along the line of rift and adjacent thereto. The valley is a portion of the great fault-rift which extends right away from the Manawatu Gorge to Hawke's Bay, in which deposits have since accumulated that have made possible the supply of artesian wells.

Ruataniwha Plain Wells.—On this plain area, which is situated 800 ft. or more above sea-level, and is within the drainage-basin of the Tukituki River, the first well was put down in 1892 by Mr. Gilberd for the late Mr. Rechab Harding (fig. 4). The well is situated north by east of the Ongaonga Township, and is 316 ft. deep. The water rose 16 ft. above the surface, giving a flow in a 3 in. well of 10 gallons per minute. Other wells had been put down in Te Ongaonga for the butter-factory, at depths varying from 78 ft. to 125 ft. In the latter well the water rises to a height of 10 ft. above the surface, and is of excellent quality and ample in quantity. Other wells have been put down, but no definite information is obtainable other than from Mr. H. N. Watson, sheep-farmer, of Fairfield, who has supplied me with very important and interesting data concerning a number of wells which he has had put down. Four wells have been sunk by him up to February, 1916, two of which were failures. The first successful well went to a depth of 390 ft., with a 3 in. pipe. The flow was at the rate of 5 gallons a minute at the surface, or 4 gallons at a height of 5 ft. A Douglas ram, size 4, was fixed in position at the 5 ft. level to supply house requirements. The well appears to undergo curious phases in its flow. Sometimes the quantity of water increases very markedly, and at times the flow changes to the consistency of pea-soup, with abundance of sand. At my suggestion Mr. Watson had the water analysed by the Government Analyst, with the following result: Sodium chloride, 1·20 grains per gallon; sodium bicarbonate, 2·50 grains; calcium bicarbonate, 4·86 grains; magnesium bicarbonate, 1·60 grains; silica, 3·92 grains: total grains, 14·08.

In Mr. Watson's letter to me from which the above information is taken the following occurs: "I have no doubt whatever, now, that the well varies its flow according to the rainfall in the Ruahines. About a month ago the water suddenly dropped one day in the tank from a level of a few inches below the house intake-pipe to just above the inflow-pipe from the ram. It remained at about the same level for a month, varying very little from day to day. On 30th June (midwinter) we had 0·19 in. of rain, but the Ongaonga Creek did not flow, and the well did not increase at all. Yesterday, although we had practically no rain and the Ongaonga

Creek has not begun to flow, there is a considerable fresh in the Tukituki, and the water was coming down very thick. It was evidently raining in the mountains, and in the evening a little rain fell here. During the afternoon I looked at the well, and thought that the water in the head-tank was rising. This morning it is overflowing at the overflow-pipe, though the ground here is hardly damp and the Ongaonga not flowing. It seems evident that my well will rise and fall in sympathy with the Tukituki River, which rises in the ranges, and not with the Ongaonga Stream, which rises in the plains."

These observations by Mr. Watson as to the changes of flow in his well are of high value, and give a clue as to the source of supply of water for the artesian wells on the Ruataniwha Plain, into and around which the Tukituki has flowed during the filling-up of the plains. It is of great importance to understand the fact that all the artesian wells found in Hawke's Bay, including Ruataniwha and Otane, are situated within the river-system of the Hawke's Bay District. Between Mr. Watson's home and the Ruahine Mountains there is one vast series of shingle terraces which slope towards the Ruataniwha Plain at a comparatively high angle, and extend from thence onward to the sea near Farndon, both by way of Waipawa and Waipukurau, but also by way of Gwavas and Maraekakaho.

The formation or building-up of the Heretaunga and Ruataniwha Plains and the Taupo Plateau is of comparatively recent date, and any facts that will help observers to determine a fair estimate of the time that has gone by since the changes occurred should be kept for future use.

The information furnished by those who answered the inquiry in a circular letter relating to the artesian wells in certain localities in this district issued by the Hawke's Bay County Council in 1916 at my request has been summarized, the consensus of opinion being that the wells gradually diminish in flow; that the wells from the shallow beds have not the same strong flow as formerly; that the wet and dry seasons alike affect the wells—the flow increasing in the former and diminishing in the latter; and that high tides increase the height of flow, the difference between high and low water being as much as 3 ft. I understand from Mr. John McDougall that a similar change of flow as between high and low water is noticeable in the artesian wells at the Lower Hutt, where the Borough Council have put down wells to supply the requirements of their town.

From what has already been stated it must now be apparent that the falling of rain upon a surface like the Heretaunga or Ruataniwha Plain cannot be used for the supply of deep underground beds in the immediate vicinity of a well. The water within an artesian area or basin is not stored water after the manner of an underground tank, but it is moving water like the flowing water in a river-bed of shingle. The Heretaunga Plain, for example, has a variety of old river-beds that have spread like fans so soon as they reached the growing plain from the higher lands of the back country. Across these fans and through the old valleys water still flows from the outcrop-beds in the back country, and it is this water that runs in the underground channels of long ago, being kept in those channels by beds of clay below them and above them, and that is tapped on its way seaward by an artesian pipe. The water in the underground beds flows from the higher areas of the plain towards the lower areas and into the sea. The slope is varied over the plain because, as already pointed out, the underlying beds represent nothing more than old flowage beds or

streams which spread over the plain as the material was deposited during periods of flooding and growth. The process can be watched even now over the plain in times of flooding. The material found during the process of sinking a well suggests the origin or place from whence the material was carried. There is a difference in the material brought down by the Tukituki compared with what is brought down by the Ngaruroro or the Tutaekuri, for the reason that the sources of the latter rivers are within the limits of the volcanic country, where pumice and lava rocks are somewhat abundant, as is also the bluish-grey clay-sand found in the vicinity of solfatara and puia. It is manifest that this water must come from somewhere outside the immediate vicinity of the water-bearing area, and thus the rainfall of the district is benefited to the extent of the amount mentioned in the early part of this paper.

From 1871 to the end of 1920 the average rainfall for the Heretaunga Plain has been 34·266 in., the rainfall for each year being as under :—

ANNUAL RAINFALL IN NAPIER AND VICINITY DURING THE PAST FIFTY YEARS.

Number of Years.	Year.	Rainfall in Inches.	Number of Years.	Year.	Rainfall in Inches.	Number of Years.	Year.	Rainfall in Inches.
1	1871	35·89	19	1889	35·76	36	1906	30·15
2	1872	23·94	20	1890	27·61	37	1907	37·65
3	1873	42·38	21	1891	29·75	38	1908	32·11
4	1874	37·94	22	1892	40·63	39	1909	36·86
5	1875	38·26	23	1893	57·73	40	1910	36·12
6	1876	38·39	24	1894	40·10	41	1911	35·29
7	1877	33·45	25	1895	34·07	42	1912	29·41
8	1878	21·00	26	1896	35·90	43	1913	25·41
9	1879	53·14	27	1897	41·38	44	1914	24·56
10	1880	38·40	28	1898	30·79	45	1915	24·56
11	1881	24·14	29	1899	37·57	46	1916	36·84
12	1882	37·01	30	1900	45·36	47	1917	46·33
13	1883	42·12	31	1901	27·77	48	1918	32·27
14	1884	39·76	32	1902	36·48	49	1919	25·13
15	1885	23·42	33	1903	31·42	50	1920	28·52
16	1886	21·67	34	1904	36·45			
17	1887	26·24	35	1905	46·67	Average	..	34·266
18	1888	21·62						

During the period there were two years when the annual rainfall exceeded 50 in., nine years when it exceeded 40 in. and was less than 50 in., twenty-one years when it exceeded 30 in. and was less than 40 in., eight years when it exceeded 25 in. and was less than 30 in., and ten years when it was less than 25 in.

These facts are of considerable importance, as they illustrate wide contrasts in the annual rainfall throughout the district, and show the importance of water-conservation. Settlers do not give much thought to the importance of rain-conservation, though after all it is the rain that supplies artesian beds with water, and were there no porous beds continuous in origin between the back country and the sea there could be no artesian wells. The drainage of a district stops the amount of soakage that was formerly possible throughout the district. When this country was first settled the areas of swamp lands were extensive. Lakes and swamp lands illustrate places where the land is oversaturated with water—in other words, where the supply of water exceeds evaporation and soakage. In sinking in depressed areas where there are no traces of water the line of

underground drainage (known as the water-table) is sometimes reached. In Napier, and, in fact, over the lower portion of the Napier area, the water-table of salt water is only a few feet from the surface, but this arises from the fact that the outer sea is only separated from the inner lagoon-basin area by a shingle-bed. The height of a water-table depends primarily on the annual rainfall of a district, and it can readily be understood how a diminished rainfall of 10 in. or 20 in. in a year must eventually affect the underground flowage, and bring into operation desiccating conditions that vitally influence underground beds in their porosity and their capacity to hold water. Up to the present time there is no regulation affecting the continuous flow of water from an artesian pipe, but the conditions are coming about that will necessitate the adoption of some form of regulation. Except for necessary supplies, all wells should be turned off to the extent of three-fourths of their flow from 6 o'clock at night to 6 on the following morning, and even in Napier the question of regulating the flowage for the borough supply, especially in summer, should receive the attention of the borough authorities.

It is urged that here, as in all other districts where artesian wells are in use, the flow of a well should be regulated, and that a stop-tap should be fixed in all cases so that the flow may be increased or decreased as required. In the case of every borough and township a pressure-gauge should be fixed on two or three of the most powerful wells, separated from each other by not less than a quarter of a mile. Many facts of public use could be gathered if the authorities would agree to work together,* and I do not doubt that the artesian beds underneath the Heretaunga Plain could be preserved for many years by careful attention to the condition of the wells. If it has been deemed necessary to establish a River-conservation Board, surely the need is as great in the matter of water-conservation for domestic use. Under a properly constituted authority a vast amount of information might be collected as to flowage, corrosion of pipes, changes in the pressure, and the changing character of the materials held in solution. These facts could be used to suggest profit and loss in the sources of supply, and the corrosion of pipes, and even as to whether creeps are taking place in overlying beds.

* Since this paper was written Mr. Berry, engineer in charge of the Napier Borough waterworks, has kept artesian-well records of pressure and flow over a definite period, and the results show that the flow is markedly influenced by the tides. Further records are being taken to test the flow at definite times—*i.e.*, 6 a.m. and 6 p.m.—without reference to tides, but carefully recording barometric pressure at the times indicated. The results will be available on another occasion.

Art. 14.—*Notes and Descriptions of New Zealand Lepidoptera.*

By Alfred Philpott, F.E.S., Assistant Entomologist, Cawthron Institute Nelson.

[*Read before the Nelson Institute, 14th September, 1921; received by Editor, 16th September, 1921; issued separately, 12th February, 1923.*]

Noctuidae.

Aletia dentata n. sp.

♂♀. 34–36 mm. Head and palpi grey mixed with fuscous, paler in ♀. Antennae grey, in ♂ fasciculate-ciliate, ciliations nearly 1. Thorax and abdomen grey, anal tuft in ♂ tinged with ochreous. Legs fuscous-grey, tarsi annulated with ochreous. Forewings moderate, costa subsinuate, apex rounded, termen evenly rounded, oblique; *grey tinged with ochreous and irrorated with dark fuscous;* a black dot on costa at base; first line very obscure, irregular, deeply indented above dorsum, whitish-ochreous, anteriorly margined with black; orbicular circular, pale-ringed; claviform very indistinct, touching first line; reniform blackish, in ♂ very indistinct, in ♀ ochreous-margined, dilated on lower half; an obscure dark median shade; second line strongly dentate, excurved to middle, thence incurved to dorsum, dentations tipped with white; a dark interrupted terminal shade, dilated on costa and enclosing three whitish-ochreous dots: cilia ochreous-grey mixed with fuscous. Hindwings dark fuscous, becoming ochreous towards base: *cilia ochreous with traces of a dark basal line.* Hindwings beneath ochreous with a broad fuscous band on termen; a dark-fuscous striga from base almost touching a prominent fuscous discal spot.

Near *A. cuneata* Philp., but distinguished by the dark coloration and the prominent ochreous cilia of the hindwings. Tongariro, 5,000 ft., in January. Mr. J. G. Myers discovered this interesting species. He found several resting during the day on rocks, and many others dead inside the mountain-hut. The types are in the collection of the Dominion Museum, to which they were presented by Mr. Myers, and a single paratype is in the collections of Mr. Myers, the Cawthron Institute, and the describer.

Hydriomenidae.

Chloroclystis punicea n. sp.

♂. 25 mm. Head green mixed with yellow. Palpi ochreous. Antennae, shaft ochreous, annulated with brown, ciliations 4. Thorax green, densely mixed with ochreous and golden scales. Abdomen green, much mixed with blackish on basal segments and with ochreous on apical ones; anal tuft whitish; a black spot on five or six median segments. Legs whitish-ochreous, anterior tarsi annulated with dark fuscous. Forewings, costa almost straight, apex abtuse, termen evenly rounded, *bright green irrorated with fuscous and sprinkled with yellow;* an indistinct curved reddish-brown basal fascia; first fascia broad, irregular, curved, reddish-brown, posterior margin broadly indented at middle; two or three indistinct curved waved lines preceding first and *the whole area flushed with pink;* median band traversed by several indistinct irregular thin fuscous lines; posterior edge of median band twice incurved on upper half, thence irregularly incurved

to dorsum, *broadly margined with a pink area posteriorly* which is traversed by several indistinct fuscous lines following the contour of the band; a serrated clear green subterminal line; termen marked with an almost continuous blackish line: cilia greyish-green barred with black. Hindwings white, tinged with pink round termen and dorsum; numerous irregular fuscous transverse lines, those on the basal half reaching only middle of wing; a dark discal dot before middle; an interrupted blackish line round termen, preceded by a greenish shade: cilia whitish-grey obscurely barred with fuscous. Hindwings beneath with a prominent blackish spot at $\frac{1}{3}$ and a median chain of blackish spots sharply angulated at middle.

Near to the *bilineolata-paralodes* group. The pink suffusion seems to be a good distinguishing character.

A single ♂ taken at Rowallan, Waiau, in December. Holotype in coll. A. Philpott.

CRAMBIDAE.

Tauroscopa notabilis n. sp.

♂. 20 mm. Head, palpi, and thorax black mixed with ochreous-whitish. Antennae black. Abdomen fuscous-black, anal tuft mixed with ochreous. Legs fuscous, tibiae and tarsi almost wholly whitish-ochreous. Forewings rather short, costa slightly arched at base, thence straight, apex rectangular, termen faintly rounded, little oblique, blackish-fuscous sprinkled with ochreous and white scales; an indistinct basal line, curved, irregular, white; *first line from $\frac{1}{3}$ costa to $\frac{2}{5}$ dorsum, dentate at middle, white*, suffusedly margined anteriorly and narrowly posteriorly with black; a discal blackish blotch in whitish median shade; *second line from $\frac{1}{4}$ costa to $\frac{4}{5}$ dorsum, weakly dentate, roundly projecting above middle, white*, narrowly margined anteriorly and suffusedly posteriorly, except at middle, with blackish; a subterminal whitish shade; a series of round black spots on termen: cilia grey, tips whitish. Hindwings pale fuscous: cilia fuscous, tips whitish.

Somewhat resembling *T. trapezitis* Meyr., but at once distinguished by the shape of the first and second lines.

Mount Peel, Nelson, in December. The unique specimen was given to me many years ago by the late Augustus Hamilton, and I deferred describing the species in the hope of obtaining further material.

Holotype (♂) in coll. A. Philpott.

PTEROPHORIDAE.

Platyptilia pulverulenta n. sp.

♂. 23 mm. Head whitish, with a projecting conical tuft of hair. Antennae reddish-brown mixed with whitish. Palpi reddish. Thorax reddish-brown densely mixed with white. Abdomen greyish-brown. Legs reddish-brown broadly banded with ochreous-whitish. Forewings narrow, apex acute, *termen of first segment concave, of second evenly rounded; reddish-brown, densely sprinkled with white on basal $\frac{2}{3}$ and more sparingly on second segment and lower half of first*; a blackish-brown triangular blotch on costa at $\frac{3}{4}$, its apex below cleft: cilia brown mingled with white. Hindwings pale reddish-brown: cilia paler; third segment with fairly even basal series of dark spatulate scales extending to near tornus.

Nearest to *P. aeolodes* Meyr., but without the subterminal white line; the evenly rounded termen of the second segment of the forewing is also a good distinguishing character.

The unique example was taken at Nelson in November, and is now in the collection of the Cawthron Institute.

Platyptilia ferruginea n. sp.

♀. 21 mm. Head bright ferruginous with many white scales. Palpi ferruginous, terminal joint mixed with white. Antennae ferruginous-grey. Thorax bright ferruginous sprinkled with white points. Abdomen ferruginous, segmental divisions mixed with white. Legs, anterior pair ferruginous mingled with white, posterior pair ferruginous, tarsi broadly annulated with white. Forewings cleft from $\frac{3}{4}$, segments rather narrow, termen of first sinuate, of second evenly rounded ; *bright ferruginous densely sprinkled with white ; costal edge blackish-red to* $\frac{2}{3}$; an elongate dark reddish-fuscous mark on fold near base ; spots of similar colour beneath costa at $\frac{1}{3}$ and on dorsum at $\frac{1}{2}$, the latter large and suffused ; a triangular blackish-brown blotch on costa at $\frac{2}{3}$, its apex below cleft ; a white spot on costa following blackish blotch ; a thin white subterminal line crossing both segments, broadly margined anteriorly with blackish-brown ; costal edge above subterminal line narrowly white : cilia ferruginous mixed with white ; a dark basal line, within cleft almost wholly whitish, on dorsum mixed with black scales almost to tornus. Hindwings, first cleft from middle, second from $\frac{1}{5}$; pale ferruginous : cilia ferruginous-grey ; on dorsum a basal line of blackish-red ; spatulate scales extending almost to tornus.

Somewhat resembling *P. falcatalis* Walk., but smaller and more brightly coloured. The forewings are narrower and the termen of the first segment is less concave. In the hindwing the prominent median tooth of scales present in *falcatalis* is absent in *ferruginea.*

A single example, secured on the Mount Arthur tableland at an elevation of about 4,500 ft. The specimen was taken late in February, on the bank of a small stream in an open place in the forest. Holotype (♀) in coll. Cawthron Institute.

TORTRICIDAE.

Epichorista emphanes Meyr., *Trans. Ent. Soc. Lond.* (1901), p. 571.
E. theatralis Philp., *Trans. N.Z. Inst.*, vol. 50, p. 128, 1918.

The acquirement of abundant material from the Mount Arthur tableland has shown me that the above correction is necessary. The female of *emphanes* is very variable, and the handsome *theatralis* is but one of the extreme forms.

Tortrix spatiosa n. sp.

♂. 27 mm. Head, palpi, and thorax purplish-brown tinged with grey, Antennae ochreous-brown, ciliations 1. Abdomen ochreous. Legs ochreous, anterior tarsi brown. Forewings moderate, fold extending to near middle of costa, *costa oblique to middle, moderately arched*, apex rectangular, termen subsinuate, rounded beneath, hardly oblique ; *purplish-brown, with ochreous suffusion ; median band slightly darker, very obscure, broadly dilated on lower portion*, anterior margin indented beneath costa ; some whitish scales on costal edge at $\frac{1}{2}$; a triangular area on costa before apex darker ; terminal area ochreous : cilia bright ochreous. Hindwings whitish-grey obscurely mottled with darker : cilia whitish, tinged with ochreous round apex and termen.

♀. 28 mm. Head, palpi, and thorax pale purplish-brown tinged with pink. Abdomen pale ochreous. Legs ochreous. *Forewings extremely strongly arched basally*, slightly sinuate before apex, apex round-pointed, termen sinuate, not oblique, rounded beneath ; *ochreous, crossed with*

numerous fine waved brownish lines; costa obscurely margined with silvery metallic scales; median fascia faintly indicated, running obliquely from costa before middle to before tornus, anterior margin indented beneath costa; a triangular purplish-brown blotch, thickly strewn with silvery metallic scales, on costa before apex: cilia ochreous, brownish at apex. Hindwings whitish, ochreous on apical ⅓: cilia whitish-ochreous, brownish round apex.

A very fine species. The male is very similar to some forms of *T. excessana* (Walk.), but is easily separated by the different costal contour of the forewing. The female is remarkable for the unusually strong basal arching of the forewing.

Mr. G. V. Hudson has examples of both sexes taken at Routeburn, Wakatipu, in February, 1911. I secured a very fine ♀ on the Dun Mountain in January, at an elevation of 2,500 ft. Holotype (♀) in coll. A. Philpott; allotype (♂) in coll. G. V. Hudson.

EUCOSMIDAE.

Eucosma plebeiana (Zell.), *Is.*, vol. 10, p. 721; Meyr., *Proc. Linn. Soc. N.S.W.*, vol. 36, p. 248, 1911.

This species has to be added to the New Zealand list, it having been taken in fair numbers at Nelson during the past summer and autumn. Nearly all the specimens were secured at light, the first example appearing early in December and the species not being over till about the end of May. From Mr. D. Miller, Government Entomologist, I learn that the moth has been reared from a larva found feeding on the leaves of *Eucalyptus*. Meyrick states that the larva feeds on *Althaea* and *Lavatera*, and was probably introduced into Australia with these plants. He adds that the species occurs now in suitable localities throughout a large part of the globe. Dr. A. Jefferis Turner, of Adelaide, who kindly determined the species for me, says that it is abundant in Australia, and has also occurred in Norfolk Island. As Zeller's description is not easy of reference to New Zealand students, I submit a brief diagnosis.

♂♀. 15–18 mm. Head and thorax dull ochreous. Forewing rather elongate, costa evenly but not strongly arched, apex obtuse, termen sinuate, oblique; grey densely irrorated with fuscous; basal patch more strongly infuscate, extending on costa to ⅓ and on dorsum to ½, upper ⅔ of margin oblique; numerous short outwardly-oblique dark strigulae along costa, longer and transverse near apex; a triangular dark-fuscous spot on tornus; in ♀ the upper half of the wing is sometimes suffused with pale ochreous: cilia grey with four or five rows of dark points. Hindwings fuscous-grey, in ♂ with an erect tuft of dense hair on and beneath Cu_1 at base: cilia grey with a thick dark basal line.

OECOPHORIDAE.

Borkhausenia xanthodesma n. sp.

♂♀. 12–15 mm. Head, palpi and thorax dark brown. Antennae dark brown annulated with yellowish. Abdomen dark brown, anal tuft yellowish. Legs greyish-ochreous. Forewings, costa slightly arched, apex broadly rounded, termen oblique; *dark brown; markings clear yellow*; a fascia almost touching base, narrow at costa, thence strongly dilated: a slightly curved, irregular-edged fascia from ¼ costa to ½ dorsum; *a*

similar fascia from ½ costa to ¾ dorsum; a narrower fascia from ⅘ costa, inwardly oblique and nearly or quite joining preceding fascia above tornus; a broad regular fascia along termen: cilia dark brown. Hindwings and cilia dark brown.

Belongs to the *chrysogramma-compsogramma* group, but differs from the former in having five yellow fasciae instead of four, and from the latter in the arrangement of the third and fourth fasciae, which do not form a definite loop as in that species.

Otago, in forest; common from November to February. On the Hunter Mountains a form occurs in which the fasciae are frequently tinged with orange-reddish. Holotype (♂), allotype (♀), and a series of cotypes in coll. A. Philpott.

Trachypepla roseata n. sp.

♂. 13 mm. Head white mixed with brown. Palpi whitish, second segment outwardly mixed with brownish-black, terminal segment with a subapical ring and some scattered scales brownish-black. Antennae brown, ciliations 1. Thorax brown mixed with white. Abdomen greyish-ochreous. Legs ochreous, tarsi banded with fuscous. Forewings moderate, apex rounded, termen oblique; greyish-brown sprinkled with dark fuscous; a small black blotch on costa at base followed by a whitish area slightly tinged with ochreous; *two tufts of rosy-pink scales at about ¼, the second obliquely above the first; a broad whitish band, enclosing some fuscous colouring, from costa at ⅖ to dorsum at ⅓,* strongly excurved; second line thin, sharply angulated outwards beneath costa, white, anteriorly margined with black on lower ⅔: cilia fuscous mixed with white. Hindwings greyish-fuscous: cilia greyish-fuscous, tips whitish.

Near *T. spartodeta* Meyr., but differing in the rosy scale tufts and the sharper angulation of the second line.

Mr. G. V. Hudson is the discoverer of this pretty species, he having taken a specimen, in rather poor condition, at Takaka, Nelson. At his desire I am describing the species from a second example, taken by myself on the Dun Mountain, Nelson, at 2,000 ft., in January. I have adopted Mr. Hudson's manuscript specific name. Holotype (♂) in coll. Cawthron Institute.

Heliodinidae.

Stathmopoda distincta n. sp.

♂♀. 13–15 mm. Head, palpi, and thorax yellowish-white, darker in female. Antennae ochreous, infuscated on apical half. Abdomen ochreous-grey. Legs whitish-ochreous. Forewings elongate, narrow, costa almost straight, apex acute, termen extremely oblique; *yellow; a thick reddish-brown outwardly-oblique bar from dorsum at ⅓, not quite reaching costa;* a similar suffused bar from costa at ⅔ to dorsum; in some examples the area surrounding bars is much irrorated with reddish-brown: cilia pale fuscous tinted with ochreous round apex. Hindwings fuscous-grey: cilia slightly paler.

Not closely related to any other species of the genus, though having some similarity in general appearance to *S. caminora* Meyr.

Dun Mountain, Nelson, in December and January. The species occurs in the forest from the base of the mountain to 3,000 ft., but it is not common. Holotype (♀), allotype (♂), and two paratypes in coll. Cawthron Institute.

GLYPHIPTERYGIDAE.

Hierodoris frigida n. sp.

♂♀. 11–13 mm. Head and thorax dark fuscous with violet and purplish metallic reflections. Palpi yellow, terminal segment infuscated. Antennae black with grey pubescence. Abdomen fuscous-black densely irrorated with shining golden scales, segmental divisions grey, anal tuft fuscous mixed with greyish-white. Legs dark fuscous, tibiae and tarsi annulated with yellowish-white. Forewings moderate, costa slightly arched, apex obtuse, termen slightly rounded, little oblique; dark fuscous mixed with black; *a broad band of scattered white scales from costa at* $\frac{1}{5}$ *to dorsum at* $\frac{1}{3}$; an irregular white spot on costa at $\frac{3}{5}$; three irregular violet-purple spots, first and second beneath costa before and beyond white costal spot, third below second, sometimes coalescing with it; *a broad subterminal band of scattered white scales*, frequently occupying the whole of the space beyond metallic spots: cilia fuscous. Hindwings dark fuscous: cilia pale fuscous with dark basal line.

Differs from *H. iophanes* Meyr. in the presence of the white bands and the arrangement of the metallic areas.

Dun Mountain, Nelson, in January. Fairly common at 3,000 ft., flying close to the ground beneath *Leptospermum* and other scrubs. Holotype (♂), allotype (♀), and a series of paratypes in coll. Cawthron Institute.

HEPIALIDAE.

Porina mimica n. sp.

♂. 34 mm. Head, palpi, and thorax dull brown. Antennae brown, in ♂ moderately dentate-ciliate. Abdomen ochreous. Legs whitish-ochreous. Forewings rather short, costa subsinuate, apex rounded, termen oblique; *pale-brownish mixed with white;* a suffused dark-brown central stripe from base to $\frac{3}{4}$, sometimes almost obsolete, enclosing the following whitish spots: *a circular one near base, two or three more or less oval ones arranged transversely at* $\frac{1}{4}$, *an irregularly triangular one at* $\frac{1}{2}$, and sometimes a small linear one immediately beyond this; a whitish shade from before apex to dorsum at $\frac{1}{2}$, enclosing a series of irregular dark-brown spots; a terminal series of white-ringed dark-brown spots, sometimes almost obsolete: cilia ochreous mixed with brown. Hindwings pale-brownish slightly tinged with ochreous: cilia greyish-ochreous mixed with brown.

♀. 38 mm. Forewings dull dark brown; the central stripe is absent or obscured and the white transverse shade is not noticeable. The triple spot at $\frac{1}{4}$ is present, but the lower one of the group is the largest. An interrupted waved white line runs from beyond apex to $\frac{1}{2}$ dorsum, and there is a series of obscure white marks following this, also a terminal chain of white lunules. The hindwings are pale fuscous.

Much smaller than *P. jocosa* Meyr., its nearest ally, and less ochreous. The antennal pectinations of the male are slightly longer in proportion.

Invercargill, in October. Holotype (♂), allotype (♀), and one male paratype in coll. A. Philpott. One male paratype in coll. G. V. Hudson.

Porina senex Huds., *Trans. N.Z. Inst.*, vol. 40, p. 107, 1908.

Only four or five specimens of this species have so far been recorded, all of which have proved to be males. Mr. F. S. Oliver has now secured the female, and that sex is so different from the other that I here give a detailed description of it.

♀. 40 mm. Head black, crown white. Palpi brown mixed with whitish. Antennae brownish-black, shortly bipectinate. Thorax dark reddish-brown, collar broadly whitish. Abdomen glossy brownish-black. Legs very dark brown, tarsi narrowly annulated with ochreous. Forewings rather short, not dilated posteriorly, costa subsinuate, apex bluntly rounded, termen bowed, very oblique; *sooty-brown; markings white;* a line beneath costa from base to $\frac{3}{4}$, where it connects with a dark-centred ring-spot; a median fascia from base, suffusedly dilated posteriorly, its lower edge almost touching a rounded spot in disc at $\frac{1}{4}$; a bent linear mark on dorsum beneath this spot; *a large elongate-oval spot beneath costa before middle;* an irregularly triangular blotch before tornus, its apex pointing towards base; *an irregular fascia from apex to disc at* $\frac{2}{3}$, enclosing one or more dark dots; some white scales round termen: cilia short, brown mixed with white. Hindwings dark fuscous with a few white marks beneath costa apically.

Mr. Oliver took a single example at Glenorchy, Wakatipu, in December, at an elevation of about 5,000 ft. He has since obtained further examples from the same locality.

MICROPTERYGIDAE.

Sabatinca demissa n. sp.

♀. 6–5 mm. Head ochreous, with a dense spreading frontal tuft of long coarse hair. Antennae ochreous, with broad blackish bands at base, at $\frac{1}{2}$, and before apex. Thorax ochreous. Abdomen fuscous-grey. Legs ochreous, tarsi annulated with blackish. Forewings rather broad, apex broadly pointed; *ochreous irrorated with dark fuscous; three or four incomplete black strigae on apical* $\frac{1}{4}$: cilia ochreous, with a black bar marking apex of wing. Hindwings and cilia grey-fuscous.

One of the smaller species, but not closely associated with *S. zonodoxa* Meyr. or *S. rosicoma* Meyr. The bi-coloured antennae and the spreading head-tufts recall *S. eodora* Meyr., but the markings are entirely different.

Three specimens taken by Dr. R. J. Tillyard at Te Wairoa Waterfall, near Lake Tarawera, in November. Holotype (♀) and a paratype in coll. Cawthron Institute.

Sabatinca incongruella Walk., *Cat. Brit. Mus.*, vol. 28, p. 511, 1863.

It may be worth while recording the discovery of the cocoon and pupal skin of this species, there being so little known about the early stages of the members of the genus. On the 9th November, 1921, a supply of a species of liverwort found growing freely at a spot where several species of *Sabatinca* had been taken was secured, and some breeding-cages fitted up, in the hope of ascertaining whether the plant had any connection with the life-history of the genus. On the 30th December a female *S. incongruella* emerged in one of these cages, and a careful search resulted in the finding of the cocoon and cast pupal skin. No other emergences took place, but it seems likely that the liverwort is the food-plant of the species, as it is improbable that the moth should have been in the pupal stage at the date when the breeding-cage was prepared.

ART. 15.—*A Study of the Venation of the New Zealand Species of Micropterygidae.*

By ALFRED PHILPOTT, F.E.S., Assistant Entomologist, Cawthron Institute, Nelson.

[*Read before the Nelson Institute, 19th October, 1921; received by Editor, 26th October, 1921; issued separately, 12th February, 1923.*]

THE Micropterygidae are represented in New Zealand by fourteen species. These are all quite small forms, the largest having a wing-expanse of about 12 mm. and the smallest barely reaching 6 mm. As the species are not of very active habits and frequent low herbage, it is probable that many more forms await discovery. The family being one of exceptional interest, and having a very important bearing on the origin of the Lepidoptera, collectors would do well to pay particular attention to the group. Our present knowledge points to the Hepaticae (liverworts) as being the food-plants of the larvae, and the imagines should be looked for near these plants; sweeping the low herbage in the vicinity is the most likely method of making captures.

At present the New Zealand Micropterygidae are placed in two genera—*Sabatinca* Walker, 1863, type *incongruella* Walk.; and *Micropardalis* Meyrick, 1912, type *doroxena* Meyr.* The former genus contains thirteen of the species, the latter being monotypic. On the venation alone, however, *Micropardalis* can hardly be sustained, Meyrick, who had but a single specimen, having fallen into error regarding the most important character, the condition of R_1 in the hindwing. Possibly, when the other structural characters are taken into consideration, the genus may prove a valid one, in which case systematic value may be placed on the point of origin of R_{4-5} in the forewing, which in *doroxena* alone is sessile on the cell.

Treating, then, for the purposes of this paper, the whole of the species as belonging to one genus, we find that this genus can be divided into three sections, the differentiating character being the condition of R_1 in the hindwing. In all the species the upper half or third of this vein has been captured by Sc_2. In two of the species, *S. lucilia* Clarke and *S. calliarcha* Meyr., the free basal portion of R_1 is present unaltered (fig. 1); in two others, *S. rosicoma* Meyr. and *S. zonodoxa* Meyr., all trace of the free part of R_1 has been lost (fig. 2); in the remaining ten forms the apical portion of the free part of R_1 occurs as a stump or "recurrent" vein projecting from Sc_2 (fig. 3). This recurrent piece varies in length in the different species, but never extends farther back than just basad of *rf'*. In *S. chrysargyra* Meyr. (fig. 4) the free end of the recurrent vein curves downwards and is connected with the radial sector by a weak cross-vein. This appears to be a secondary development confined to the one species, as a

* I do not include the genus *Mnesarchaea* Meyr., as I think that Tillyard (*Proc. Linn. Soc. N.S.W.*, vol. 44, p. 118, 1910) has shown sufficient reason to justify its removal from the family.

weak cross-vein connects Rs and Sc at about $\frac{1}{3}$, probably marking the point at which R_1 originally left the radial sector. This latter cross-vein occurs in several of the species.

When we come to examine the venation in detail we find that the condition of R_1 is the only factor that can be used to separate the three

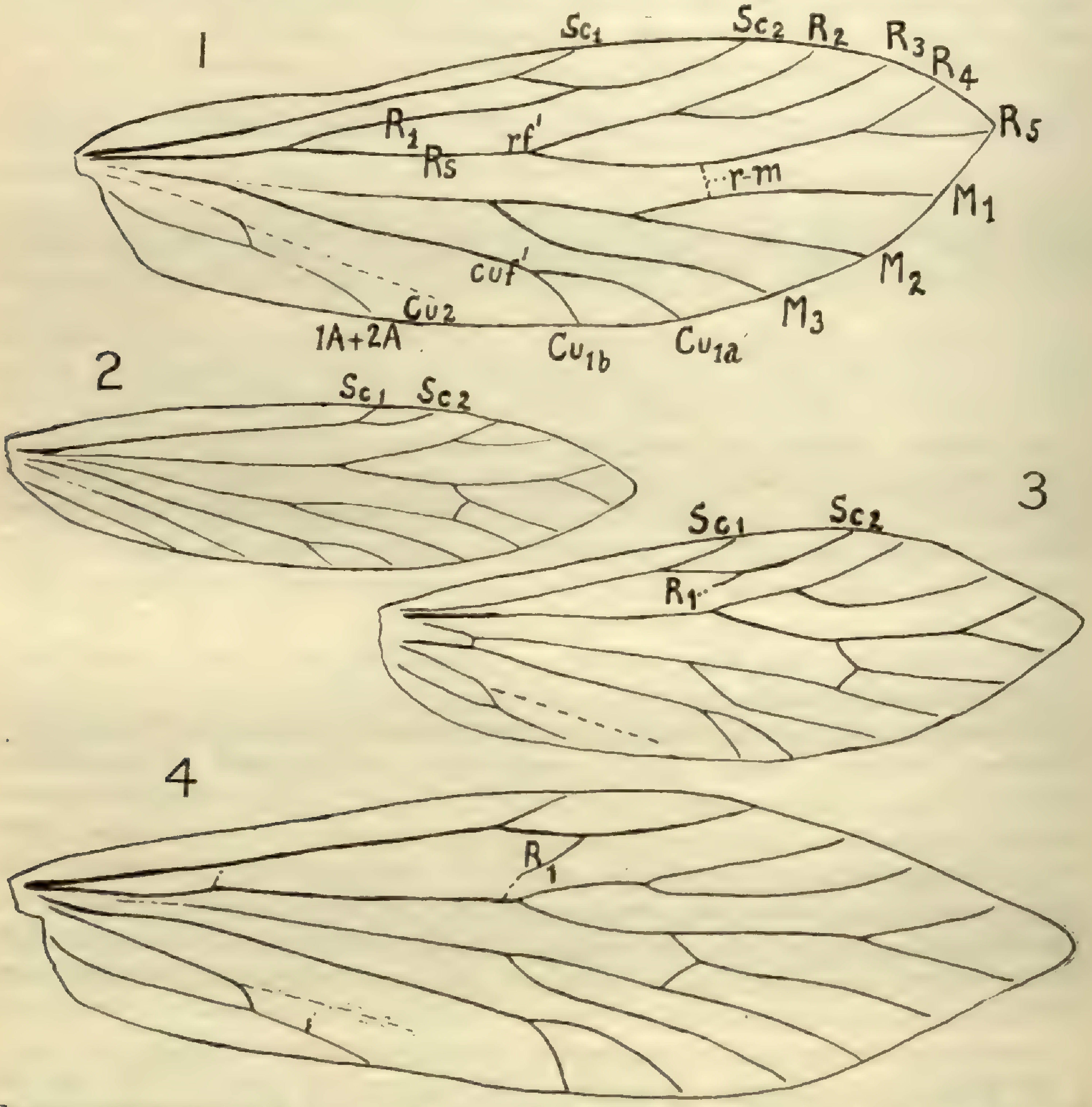

FIG. 1.—Hindwing of *Sabatinca lucilia* Clarke. (Lettering: 1A, 2A, first and second anals; Cu_2, second cubitus; Cu_{1a} and Cu_{1b}, branches of the first cubitus; *cuf'*, secondary cubital fork; M_1, M_2, M_3, primary branches of the media; R_1, primary branch of the radius; R_{2-3}, R_{4-5}, secondary branches of the radial sector; Rs, radial sector; *r-m*, radio-median cross-vein: *rf'*, secondary radial fork; Sc_1, Sc_2, branches of the subcosta.)

FIG. 2.—Hindwing of *Sabatinca rosicoma* Meyr. Note entire absence of R_1 as a free vein. (For lettering see fig. 1.)

FIG. 3.—Hindwing of *Sabatinca incongruella* Walk., to show "recurrent vein," R_1. (For lettering see fig. 1.)

FIG. 4.—Hindwing of *Sabatinca chrysargyra* (Meyr.). Note the joining-up of the stump of R_1 to the radial sector by formation of a cross-vein. (For lettering see fig. 1.)

sections. A good deal of variation occurs between the different species, but nothing that can be said to be definitely correlated with the state of development of the basal part of R_1 in the hindwing.

I now give a list of the species, and a detailed account of the venation of the genus, with figures to illustrate certain specific variations.

LIST OF SPECIES.

Sabatinca incongruella Walk., *Cat. Brit. Mus.*, vol. 28, p. 511, 1863; *Palaeomicra chalcophanes* Meyr., *Trans. N.Z. Inst.*, vol. 18, p. 182, 1886.
—— *chrysargyra* (Meyr.), *Trans. N.Z. Inst.*, vol. 18, p. 182, 1886.
—— *zonodoxa* (Meyr.), *Trans. N.Z. Inst.*, vol. 20, p. 91, 1888.
Micropardalis doroxena (Meyr.), *Trans. N.Z. Inst.*, vol. 20, p. 92, 1888.
Sabatinca caustica Meyr., *Trans. N.Z. Inst.*, vol. 44, p. 124, 1912.
—— *calliarcha* Meyr., *Trans. N.Z. Inst.*, vol. 44, p. 124, 1912.
—— *quadrijuga* Meyr., *Trans. N.Z. Inst.*, vol. 44, p. 126, 1912.
—— *rosicoma* Meyr., *Trans. N.Z. Inst.*, vol. 46, p. 118, 1914.
—— *aurella* Huds., *Ent. Mo. Mag.*, vol. 4, p. 62, 1918.
—— *barbarica* Philp., *Trans. N.Z. Inst.*, vol. 50, p. 132, 1918.
—— *eodora* Meyr., *Trans. N.Z. Inst.*, vol. 50, p. 134, 1918.
—— *lucilia* Clarke, *Trans. N.Z. Inst.*, vol. 52, p. 35, 1920.
—— *ianthina* Philp., *Trans. N.Z. Inst.*, vol. 53, p. 342, 1921.
—— *demissa* Philp., this volume, p. 154.

VENATIONAL VARIATION.

The Forewing.

Humeral Veinlet (*hm*).—The humeral veinlet varies greatly in strength. Its condition has some reference to the shape of the wing at the base; where the costa is deeply hollowed out, or the wing narrowed in some other way, as in *Sabatinca calliarcha*, *S. chrysargyra* (fig. 5), or *S. barbarica*, *hm* has almost disappeared.

Subcostal Vein (Sc).—The upper fork (Sc_1) is well developed in all the species.

Subcosto-radial Cross-vein (Sc-r).—This cross-vein is present in *lucilia*, *ianthina*, *doroxena*, *calliarcha*, *caustica*, *quadrijuga*, *eodora*, and *chrysargyra*. In the last three it is usually very weak. It is absent in *incongruella*, *aurella* (a trace sometimes), *barbarica*, *demissa*, *rosicoma*, and *zonodoxa*. In the last two there is not even a bend in the veins to indicate where the cross-vein originally joined.

Radius (R).—The radius forks into R_{1a} and R_{1b} before ½ in all species; both branches are strong, well-developed veins.

Radial Sector (Rs).—The radial sector is twice dichotomically forked, giving rise to the branches R_2 to R_5. In *lucilia* the secondary radial fork is situated farther basad than in any other species, the next farthest being *calliarcha*. The forking of R_{2-3} is fairly uniform as to position in all the species, but that of R_{4-5} varies considerably. In *demissa*, *rosicoma* (fig. 6), *zonodoxa*, and *caustica* R_{4-5} is short-stalked; in *eodora*, *barbarica*, *calliarcha*, and *incongruella* the stalking is medium (about half-way); in *chrysargyra*, *aurella*, and *quadrijuga* the vein is long-stalked; in *lucilia* and *ianthina* the branches are connate in origin, while in *doroxena* fig. (7) the forking is basad of the discocellular cross-veins—that is, the branches are sessile on the cell. The branching of R_{4-5} is in general correlated with the breadth of the apical portion of the wing, those species in which the wing is narrowest having the shortest forks.

Fourth Median Vein (M_4).—M_4 usually rises from M_3 a little distad of *mf'*; it connects with Cu_1 at the forking of the latter so that in some cases its apex is farther distad than its base. This arrangement is most noticeable in *lucilia* and *calliarcha*. In *rosicoma* and *zonodoxa* the point

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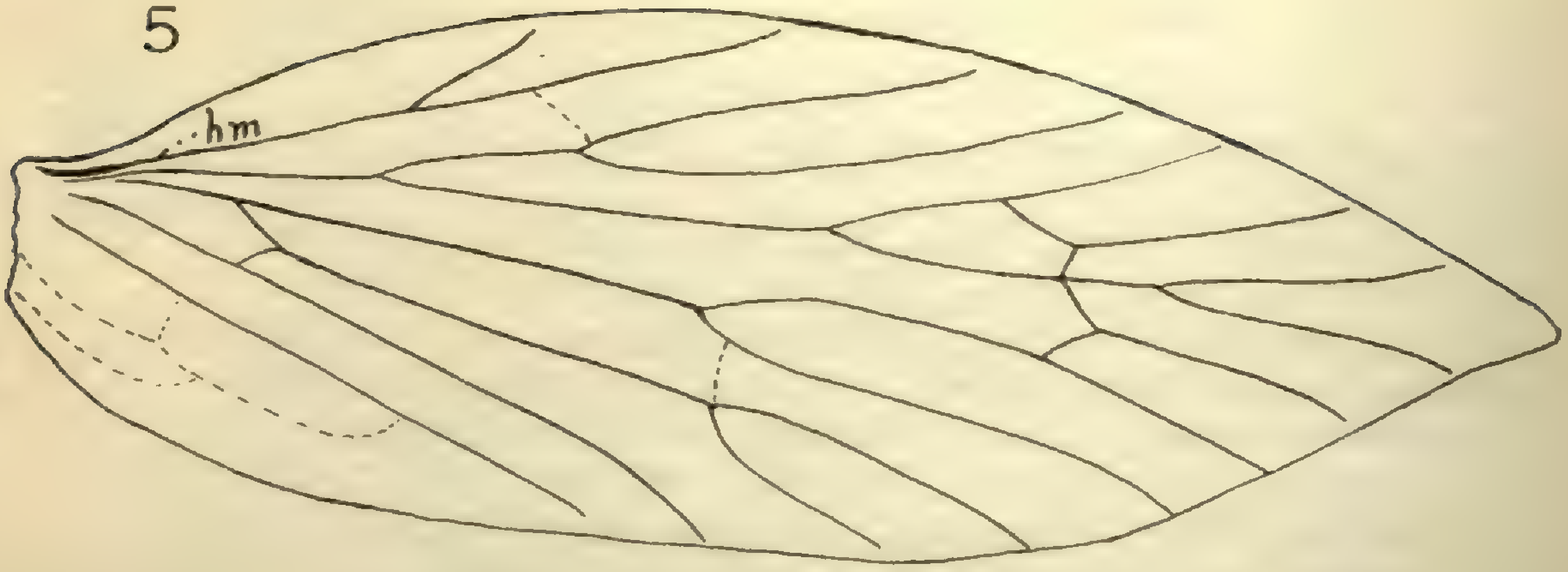

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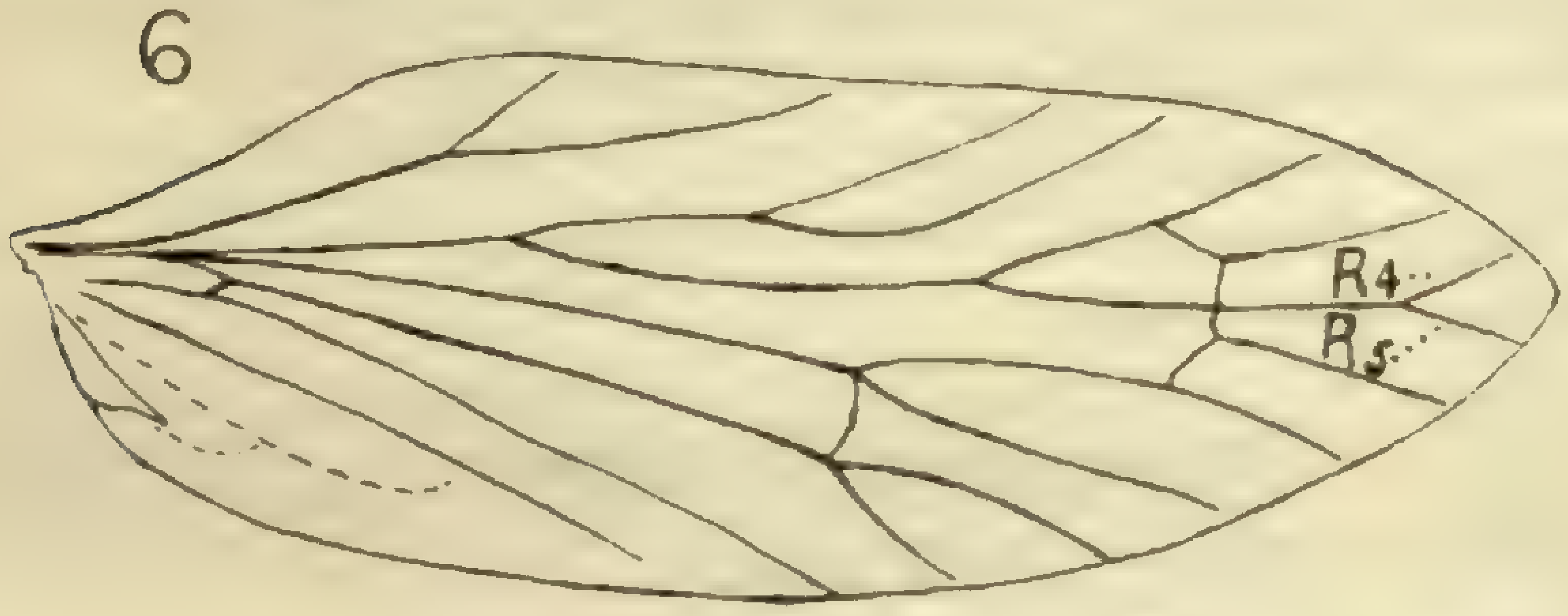

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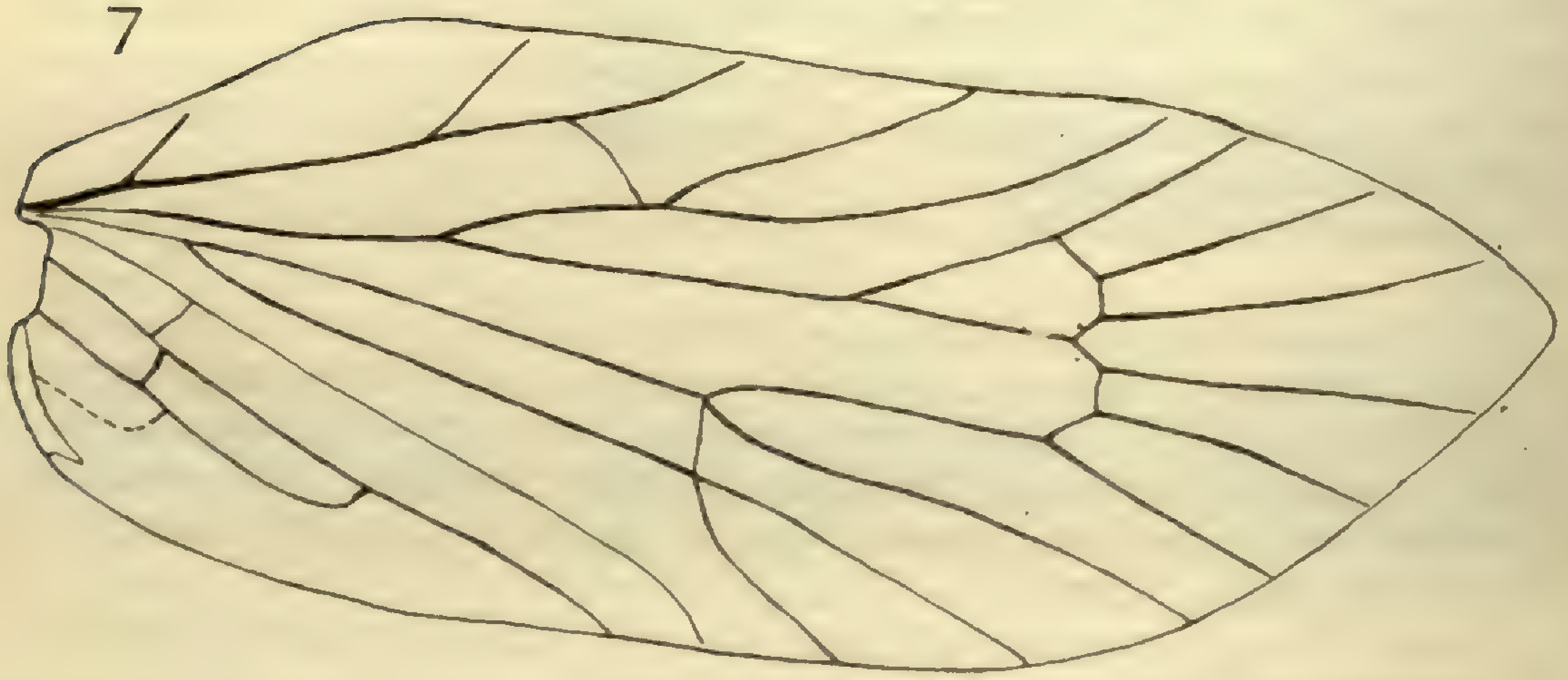

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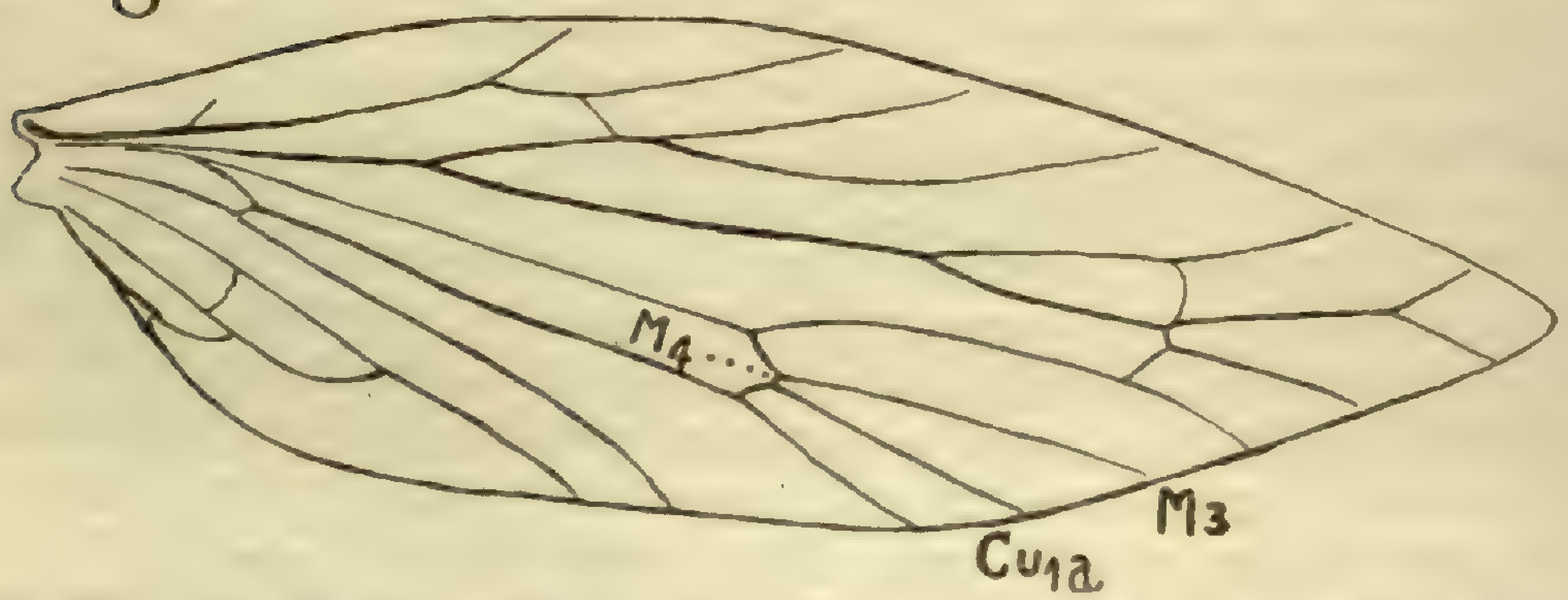


FIG. 5.—Forewing of *Sabatinca chrysargyra* (Meyr.). Note reduction of *hm.* (For lettering see fig. 9.)

FIG. 6.—Forewing of *Sabatinca rosicoma* Meyr. (For lettering see fig. 9.)

FIG. 7.—Forewing of *Micropardalis doroxena* (Meyr.). Note origin of R_{4-5}. (For lettering see fig. 9.)

FIG. 8.—Forewing of *Sabatinca caustica* Meyr., to show reduction of M_4.

of origin of M_4 is *mf′*. In *caustica* (fig. 8) M_4 is very short, rising well along M_3 and connecting almost at once with Cu_{1b}, which bends strongly towards the former vein. A very slight further reduction of M_4 would mean its total disappearance, resulting in the connection of M_4 and Cu_{1b} at the point.

Cubito-median Y-Vein.—In several species the cubito-median *Y*-vein is more or less obsolete. It is fairly well developed in *lucilia*, *calliarcha*, *doroxena*, *chrysargyra*, and *aurella*—that is, in those forms in which the

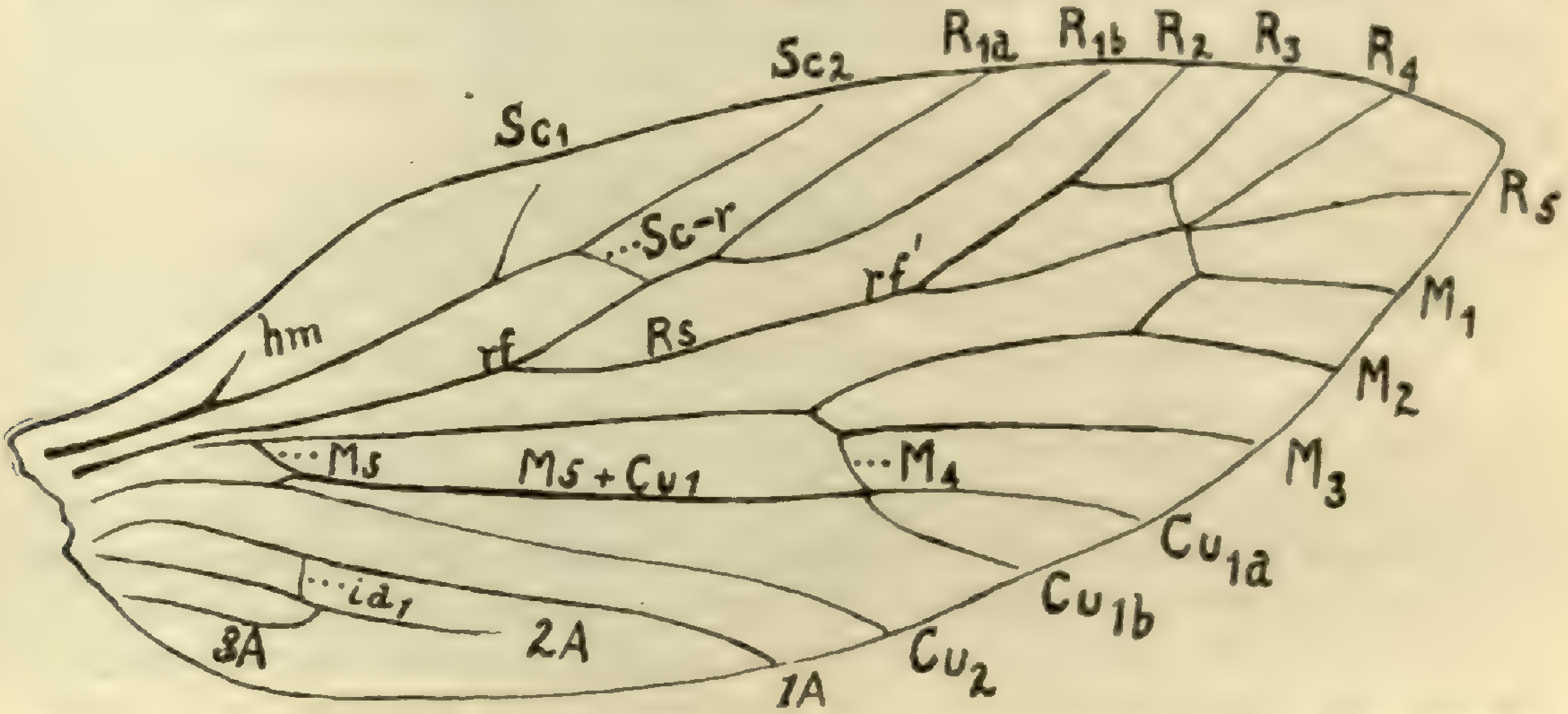


FIG. 9.—Forewing of *Sabatinca ianthina* Philp. (Lettering: 1A, 2A, 3A, first, second, and third anals; Cu_1, Cu_2, primary branches of the cubitus: Cu_{1a}, Cu_{1b}, branches of Cu_1; *hm*, humeral veinlet; ia_1, first inter-anal cross-vein; M_{1-5}, primary branches of the media; Rs, radial sector; *rf*, primary radial fork; *rf′*, secondary radial fork; R_{1a}, R_{1b}, branches of R_1; R_{2-3}, R_{4-5}, branches of the radial sector Sc_1, Sc_2, branches of the subcosta; *sc-r*, subcosto-radial cross-vein.)

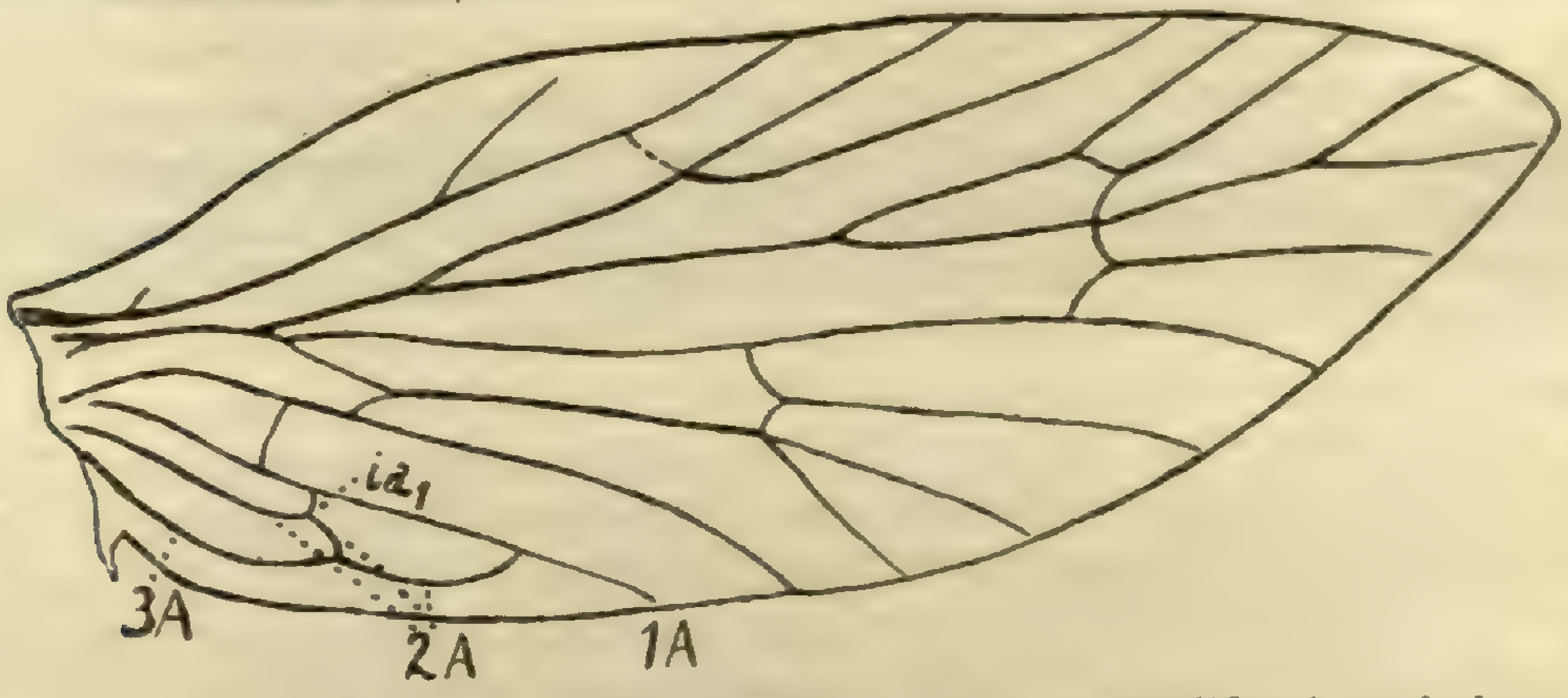


FIG. 10.—Forewing of *Sabatinca calliarcha* Meyr., to show modification of the anals. (For lettering see fig. 9.)

wing is broader basally—but in the narrower-winged species it has almost disappeared. The upper branch (M_5) is always the longer and more prominent of the two.

Cubito-anal Cross-vein (Cu-a).—This cross-vein is present in *lucilia*, *calliarcha*, *doroxena*, *barbarica*, *ianthina*, *rosicoma*, *incongruella*, and *demissa*, though very weak in the last five; it is absent in *zonodoxa*, *quadrijuga*, *eodora*, *caustica*, *chrysargyra* (a trace), and *aurella*. Its presence or absence does not seem to be of any significance, as it is not correlated with any other structure.

First Inter-anal Cross-vein (ia_1).—All the species have this cross-vein, except *demissa*, *barbarica*, *rosicoma*, and *zonodoxa*. Its absence is accompanied by a weakening of the anal veins.

Anal Veins (1A, 2A, *and* 3A).—The arrangement of the anal veins is very peculiar, and varies little throughout the genus. At about two-thirds of its length 2A curves sharply upwards and joins 1A, 3A following a similar course in relation to 2A. In one species, however, *ianthina* (fig. 9), 2A does not join 1A or curve towards it. In *calliarcha* (fig. 10) 2A bends towards 1A at *ia*, and from thence sharply downwards again, thus giving an unusual appearance to what is essentially the same structure. In some of the species the anal veins are very weakly chitinized, and can only be traced with difficulty.

The Hindwing.

Subcostal Vein (Sc).—Sc forks into Sc_1 and Sc_2 in all of the species. In a few of the forms an interesting feature is present in connection with the stalk of the vein. In *doroxena* this appears to consist of two veins lying closely alongside each other, but not fused, the condition being observable from the normal forking to near the base—that is, for at least four-fifths of the stalk. In *calliarcha* the division can be traced nearly to *rf*, and the vein is of double width for some distance basad of this. In *lucilia* the double nature of the vein is obscure near the normal forking, but becomes more pronounced farther basad, while in *ianthina* the division is apparent for about one-third of the apical portion.

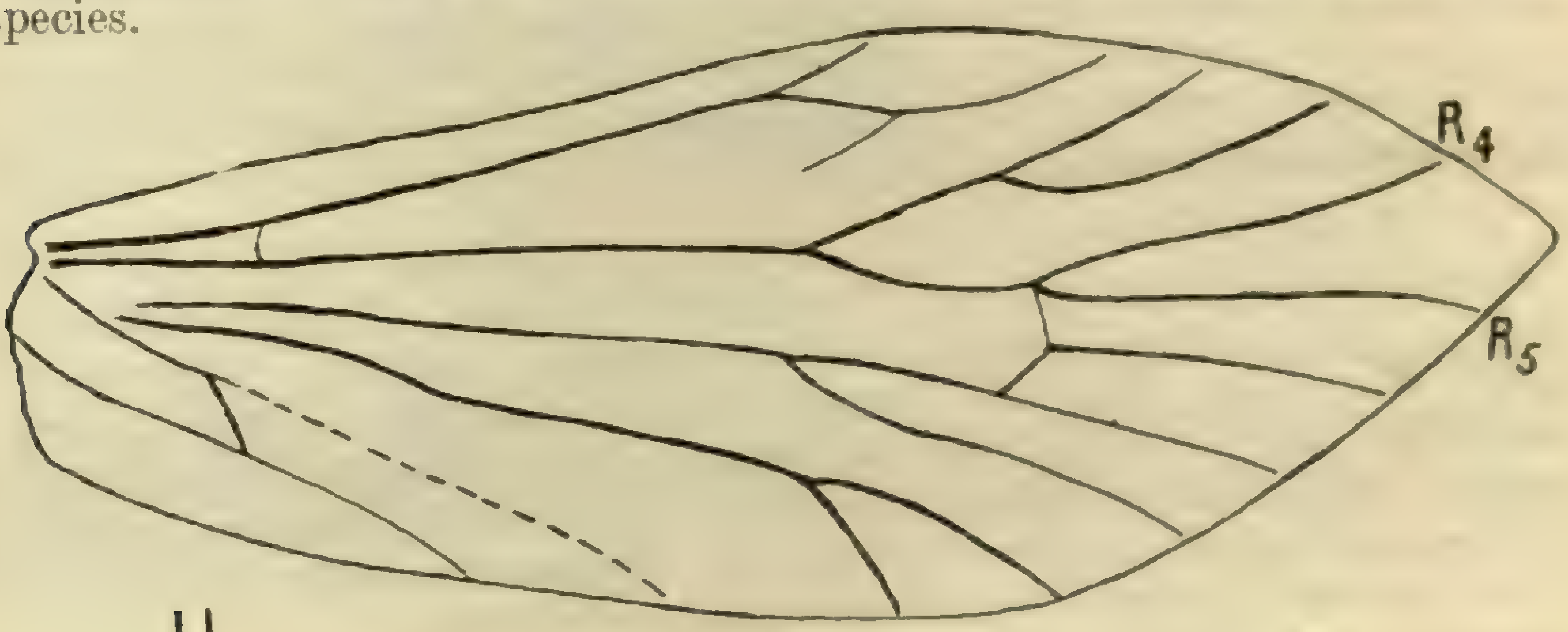
The basal dichotomy of Sc is not known in any living insect, but Tillyard has shown (*Proc. Linn. Soc. N.S.W.*, vol. 44, p. 548, 1919) that in the fossil *Archipanorpa* (order Protomecoptera), though the basal part of the wing is missing, the apical portions of Sc are in such a position as to point to a junction far basad, while in *Aristopsyche* (order Paratrichoptera) the actual basal fork is observable. It is not, however, claimed that in this apparent double vein in the foregoing species we have an indication of the persistence of so remote an ancestral character as the basal forking of the subcostal vein. Dr. Tillyard, who has seen my preparations, suggests the following explanation: "The double formation is a specialization of the imaginal venation following upon an exceptionally strong splitting-back of the precedent subcostal trachea in the pupal wing. It is well known that in the order Lepidoptera the wing-tracheae tend to split back into separate tracheae running alongside one another to points far basad from the normal points of forking of the vein. If two such tracheae became slightly more separated, the superimposed chitinization at metamorphosis would produce a double vein in the imago. This seems to be what has actually happened in the case here under discussion."

Radius (R).—As R_1 has been fully dealt with in the earlier part of the paper, the details need not be repeated here. The radial sector is twice dichotomically forked as in the forewing, but there is greater variation in the length of the stalk, particularly in regard to R_4 and R_5. In *doroxena* (fig. 11) R_4 and R_5 are connate; in *aurella* and *ianthina* they are short-stalked; in *barbarica*, *quadrijuga*, *incongruella*, *eodora*, and *zonodoxa* the forking is from about half-way; while in *rosicoma*, *lucilia*, *calliarcha*, *chrysargyra*, *demissa* (fig. 12), and *caustica* the stalk is long. R_2 and R_3 are more uniform in the length of stalk, but in the only specimen of *caustica* examined R_3 was absent; quite possibly, however, this was merely an individual variation.

Median Veins (M_{1-4}).—The secondary median fork (*mf'*) is basad to the secondary radial fork (*rf'*) in *incongruella, lucilia, caustica, barbarica, rosicoma,* and *zonodoxa*; in *calliarcha mf'* is distad to *rf'*, and in all the other forms the position of these forks is about equal. The relative position of the forks seems to be of little importance, as, if insisted on, it would divide such closely related forms as *lucilia* and *calliarcha*.

There is no trace of the fourth median vein in any of the species.

First Cubital Vein (Cu_1).—In *doroxena* Cu_1 is more remote from M_3 than in any other species: it may be noted that *doroxena* is the broadest-winged form. There is no cross-vein between Cu_{1a} and M_3 in any of the species.



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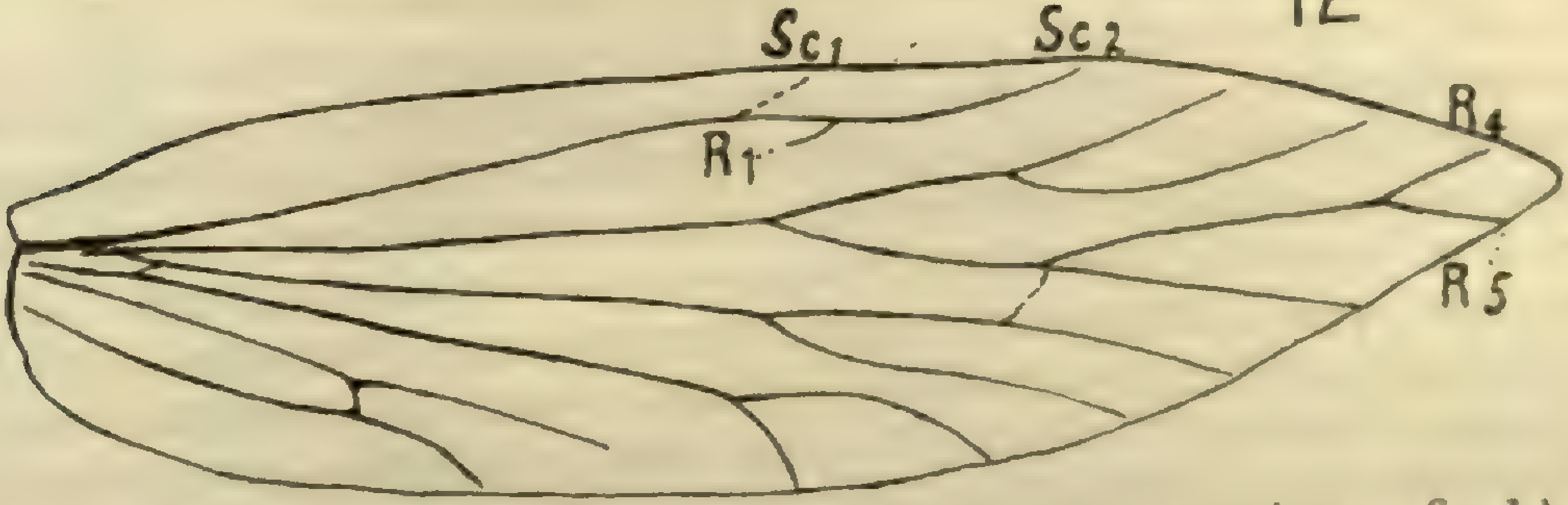

FIG. 11.—Hindwing of *Micropardalis doroxena* (Meyr.). (For lettering see fig. 1.)
FIG. 12.—Hindwing of *Sabatinca demissa* Philp. (For lettering see fig. 1.)

Second Cubital (Cu_2), *and Anal Veins* (1A, 2A *and* 3A).—Cu_2 is captured by 1A for about half its length, at which point it bends downwards and joins 2A, Cu_2 continuing alone as a very weak vein. This condition occurs in all the species except *rosicoma* and *zonodoxa*, in which forms the anal are very weak and 1A does not leave Cu_2 to connect with 2A.

In conclusion, I have pleasure in expressing my gratitude to Mr. G. V. Hudson, F.E.S., F.N.Z.Inst., and Mr. Charles E. Clarke, F.E.S., for specimens of some of the more rare forms of the genus, without the opportunity of examining which my paper must have lacked completeness. Mr. Clarke kindly supplied me with several specimens of *rosicoma*, and also with a pair of his *lucilia*, a form which I think must be regarded as the most primitive in the genus. To Mr. Hudson's generosity I am indebted for an example of *zonodoxa*, the gift being all the more appreciated as the specimen was one of the only two examples of this form in New Zealand collections. To Dr. Tillyard, Chief of the Biological Department of the Cawthron Institute, I am under a deep obligation for much valuable advice. To all these gentlemen I desire to express my best thanks.

Art. 16.—*Descriptions of New Zealand Lepidoptera.*

By E. Meyrick, B.A., F.R.S.

Communicated by G. V. Hudson, F.E.S., F.N.Z.Inst.

[*Read before the Wellington Philosophical Society, 30th September, 1921; received by Editor, 13th October, 1921; issued separately, 12th February, 1923.*]

The whole of the new species following were received from my friend Mr. G. V. Hudson; they include some forms of special interest, and some unique specimens which he has very generously placed at my service.

Crambidae.

Diptychophora planetopa n. sp.

♂. 11 mm. Head whitish-ochreous mixed with grey. Palpi grey with ochreous-yellowish median spot, towards base whitish. Thorax dark grey, patagia pale ochreous with a dark-grey stripe. Abdomen rather dark grey. Forewings triangular, termen slightly bisinuate; dark fuscous, somewhat mixed with whitish-ochreous in disc; anterior half of costa suffused with whitish-ochreous; first line rather thick, irregular, whitish-ochreous on upper half and white on lower, edged with cloudy dark-fuscous lines, angulated outwards in middle and inwards towards dorsum, preceded by a fascia of whitish-ochreous suffusion marked with white below middle; a rather large round snow-white discal spot beyond middle, above which is a white dot; second line fine, white, interrupted into minute lunules, excurved from near costa to below middle; a white dot near apex; a terminal series of six rather cloudy black triangular spots, preceded by a series of irregular brownish-ochreous spots, at apex an elongate brownish-ochreous spot, a minute white mark beneath uppermost black spot: cilia dark grey, with fine indistinct whitish basal and median lines, and indistinct slender whitish bars beneath apex, in middle, and above tornus. Hindwings rather dark grey; cilia light grey with whitish median and apical shades.

Routeburn Valley, Lake Wakatipu, in forest, February; one example. Very distinct.

Pyraustidae.

Scoparia zophochlaena n. sp.

♂. 18 mm. Head ferruginous-ochreous, face fuscous. Palpi 2¼, light grey mixed with whitish. Antennal ciliations ¼. Thorax dark fuscous. Abdomen ochreous-grey-whitish, anal tuft whitish-ochreous. Forewings elongate-triangular, termen gently rounded, faintly sinuate beneath apex, somewhat oblique; light ochreous-brownish; first line double, irregular, white, from $\frac{1}{5}$ of costa to $\frac{1}{3}$ of dorsum, suffusedly blotched with ferruginous-ochreous above and below middle, basal area within this almost wholly black; second line fine, white, from $\frac{4}{5}$ of costa to $\frac{3}{4}$ of dorsum, gently excurved, indented at $\frac{1}{4}$ from costa, nearly preceded by a more curved fascia of whitish suffusion broadest towards extremities, space between these blackish towards costa; space between first line and the whitish fascia forming a trapezoidal costal blotch of blackish suffusion, its anterior lower angle resting on dorsum beyond first line and posterior on middle of fascia; second line followed by a blackish transverse blotch from costa hardly reaching half across wing, and some irregular blackish marking

towards dorsum; an almost terminal series of small roundish spots of blackish irroration: cilia whitish-grey, with grey subbasal shade. Hindwings ochreous-whitish, with an apical blotch of light-grey suffusion; cilia whitish, with grey subbasal line.

Takapuna, Auckland, in January; one example. Conspicuous by the large development of black blotches; probably most allied to *acharis*.

TORTRICIDAE.

Epichorista emphanes Meyr.

On the 21st December, 1920, Mr. Hudson found this species abundant at Gollan's Valley, Wellington, in company with *Harmologa achrosta* Meyr., and observed that all examples of *emphanes* were ♀ and all *achrosta* ♂, and also took a pair *in cop.*; he therefore concluded that these forms are sexes of the same species, and this is undoubtedly correct, being borne out by examination of the series in his collection. The two forms are so different in appearance that I should not have suspected their identity, never having met with them alive myself. This discovery further called my attention to the fact that the genus *Harmologa*, originally based on a few species, has now through considerable accretions become heterogeneous and requires subdivision. I therefore reclassify this group of species as under:—

Gelophaula n. g.

Antennae in ♂ stout, simple, or very minutely pubescent. Palpi long, porrected, clothed with dense rough scales diminishing to apex, beneath with long rough hairs towards base, in ♀ less developed. Thorax without crest. Forewings 7 and 8 separate, 7 to termen. Hindwings without cubital pecten, 3–5 approximated at base, 6 and 7 closely approximated at base or short-stalked.

Type, *trisulca* Meyr. Includes also *aenea* Butl., *tritochlora* Meyr., *tributaria* Philp., *siraea* Meyr., *lychnophanes* Meyr., *palliata* Philp., *brevicula* Meyr.

Epichorista Meyr.

Antennae in ♂ moderately or rather strongly ciliated. Palpi moderate or long, porrected, second joint dilated with dense scales above and beneath. Thorax without crest. Forewings 7 and 8 separate, 7 to termen. Hindwings without cubital pecten, 3–5 approximated at base, 6 and 7 closely approximated at base or short-stalked.

Type, *hemionana* Meyr. Includes also *elephantina* Meyr., *persecta* Meyr., *tenebrosa* Philp. (not seen), *siriana* Meyr., *aspistana* Meyr., *eribola* Meyr., *zatrophana* Meyr., *emphanes* Meyr. (= *achrosta* Meyr.), *allogama* Meyr., *crypsidora* Meyr.

Harmologa Meyr.

Antennae in ♂ moderately or rather strongly ciliated. Palpi moderate or long, porrected, second joint dilated with dense scales above and beneath. Thorax with small posterior crest. Forewings 7 and 8 separate, 7 to termen. Hindwings without cubital pecten, 3–5 approximated at base, 6 and 7 closely approximated at base or short-stalked.

Type, *oblongana* Walk. Includes also *amplexana* Zell., *scoliastis* Meyr., *antitypa* Meyr., *sisyrana* Meyr., *pontifica* Meyr., *sanguinea* Philp., *festiva* Philp.

Philocryptica n. g.

Antennae in ♂ rather strongly ciliated. Palpi rather short, obliquely ascending, second joint with tolerably appressed scales. Thorax with strong double posterior crest. Forewings 7 and 8 separate, 7 to termen. Hindwings without cubital pecten, 3 approximated at base to 4, 4 and 5 short-stalked, 6 and 7 stalked.

Type, *polypodii* Watt, for an example of which I am indebted to Mr. Hudson.

Ecclitica n. g.

Antennae in ♂ strongly fasciculate-ciliated. Palpi rather short, subascending, second joint with short rough scales appressed towards base. Thorax with strong double posterior crest. Forewings 7 and 8 separate, 7 to termen. Hindwings without cubital pecten, 3 and 4 closely approximated at base or almost connate, 5 little approximated, 6 and 7 stalked.

Type, *hemiclista* Meyr. Includes also the following new species :—

Ecclitica incendiaria n. sp.

♂. 14 mm. Head and palpi fuscous. Antennal ciliations 2. Thorax dark purplish-fuscous somewhat mixed with ferruginous. Abdomen dark grey. Forewings rather elongate-triangular, costa slightly arched, with moderate fold from base to beyond ⅓, apex obtuse, termen somewhat rounded, rather oblique ; ashy-grey, with faint violet tinge ; costal fold dark fuscous with three pale-ochreous spots ; dorsal area on basal third irregularly marked with dark fuscous and mixed with ferruginous ; central fascia oblique, irregular-edged, dark fuscous, costal third very narrow, remainder broad but containing several small grey or ferruginous spots and marked on dorsal edge with three small white spots ; costal edge on posterior half whitish between dark markings ; two small dark-fuscous spots on costa beyond central fascia, whence slender ferruginous streaks mixed with dark fuscous run into broad part of fascia ; two transverse ferruginous spots on costa about ⅔, blackish on costa, confluent and mixed with blackish beneath, connected beneath with a median prominence of a blackish streak running from costa near apex to tornus, edged in front with slight ferruginous suffusion, dorsal edge white before this ; some dark-fuscous strigulation along termen : cilia dark fuscous, tips somewhat mixed with brownish. Hindwings dark grey ; cilia grey, with dark-grey subbasal line.

Mount Egmont, 4,000 ft., February ; one example.

Eucosmidae.

Spilonota macropetana Meyr., *Proc. Linn. Soc. N.S.W.*, vol. 6, p. 683, 1881.

Auckland, from *Eucalyptus* ; one ♂ example received by Mr. Hudson from the Department of Agriculture. Not previously noticed from New Zealand ; the species is a native of Australia, where it is common and widely distributed, and has doubtless been artificially introduced with *Eucalyptus*, which is its food-plant.

Gelechiadae.

Sitotroga cerealella Ol., *Staud. Cat. Pal. Lep.*, No. 2902 ; Meyr., *Proc. Linn. Soc. N.S.W.*, vol. 29, p. 286, 1904.

Levin, December ; one example received by Mr. Hudson from the Department of Agriculture. Apparently not previously recorded from New

Zealand, but I am surprised it has not been found earlier; it is generally spread in all countries not too cold as a pest of stored grain (wheat, rice, &c.), to which the larva is very destructive; it is abundant in Australia. It may be looked for in corn-bins and granaries. The full synonymy and list of references is considerable.

Apatetris melanombra Meyr.

Having received an example of *Gelechia sparsa* Philp. from Mr. Hudson, I find it to be a synonym of this species. The genus *Apatetris* Staud. I have adopted as superseding *Epiphthora* Meyr.

OECOPHORIDAE.

Chersadaula n. g.

Head loosely haired; ocelli posterior; tongue developed. Antennae ¾, in ♂ evenly ciliated, basal joint moderate, without pecten. Labial palpi rather long, recurved, second joint thickened with appressed scales, terminal joint about half second, slender, acute. Maxillary palpi very short, filiform. Posterior tibiae rough-scaled above. Forewings 1*b* furcate, 2 and 3 stalked from angle, 7 and 8 stalked, 7 to costa, 11 from middle; in ♀ half-aborted, pointed. Hindwings in ♂ 1, elongate-ovate, cilia ¾; 3 and 4 connate, 5–7 nearly parallel; in ♀ half-aborted, very short, lanceolate.

An interesting development of *Borkhausenia*.

Chersadaula ochrogastra n. sp.

♂. 17 mm. Head ochreous-whitish, hairs greyish towards base. Palpi ochreous-whitish mixed with grey. Antennal ciliations ♂ 1½. Thorax ochreous-whitish slightly tinged with rosy, and suffusedly mixed with grey. Abdomen light yellow-ochreous. Forewings elongate, costa slightly arched, apex obtuse, termen very obliquely rounded; light-brownish irregularly tinged with rosy-pink, and sprinkled with grey-whitish and dark fuscous; a dark-fuscous dot on base of costa; a spot of dark-fuscous irroration in disc towards base; stigmata roundish, dark fuscous, plical beneath first discal, opposite spots of dark-fuscous suffusion on costa and dorsum before these two and suffusedly connected with them, plical preceded by some white suffusion, a roundish blotch of dark-fuscous irroration between second discal and tornus, preceded by narrow whitish suffusion; an irregular ill-defined and incomplete angulated subterminal line of dark-fuscous irroration, indented above angle: cilia pale ochreous tinged with rosy, base sprinkled with dark fuscous. Hindwings dark grey, lighter towards base; cilia grey.

♀. 16 mm. Abdomen yellow-ochreous, grey on sides and praeanal segment, anal segment whitish. Forewings broad-lanceolate, apex strongly and narrowly produced, pointed; colour and markings nearly as in ♂, but basal third more whitish, angularly prominent in disc, a stronger blackish mark between second discal and tornus. Hindwings rather broad-lanceolate, less than half length of forewings and about half as broad: cilia grey-whitish.

Breaker Bay, Wellington; bred in November from larvae found under stones on the coast in September; two examples. The female must be incapable of flight—probably an adaptation to a shelterless and windy coast.

Izatha manubriata n. sp.

♂. 26 mm. Head and thorax grey suffused with white except shoulders. Palpi white, second joint sprinkled with blackish, and with a black subapical

ring, terminal joint with black median band. Abdomen grey, segmental margins whitish, anal tuft ochreous-whitish. Forewings elongate, posteriorly rather dilated, costa slightly arched, apex obtuse, termen nearly straight, oblique; grey suffusedly irrorated with white, tinged here and there with ochreous; a small grey basal patch, edge sprinkled with blackish, acutely angulated on fold; small blackish spots on costa at $\frac{1}{3}$ and $\frac{3}{5}$; stigmata blackish, plical beneath first discal, second discal represented by a small transverse spot from which a blackish streak runs nearly to first, a blackish dot between and above first and second discal; an obscure angulated subterminal shade of whitish suffusion; a marginal series of small blackish-grey spots round posterior part of costa and termen: cilia whitish with two grey shades. Hindwings grey; cilia as in forewings.

Ben Lomond, Lake Wakatipu, in forest at 2,000 ft., January; one example.

Cryptolechia rhodobapta n. sp.

♂. 19 mm. Head and thorax rosy-fuscous. Palpi light rosy partially suffused with fuscous. Abdomen pale-greyish tinged laterally with rosy, anal tuft whitish-ochreous. Forewings elongate, moderate, costa moderately arched, apex obtuse, termen slightly rounded, somewhat oblique; 2–4 approximated, 7 to apex; rosy-lilac-brownish, costal edge ferruginous: stigmata small, indistinct, dark fuscous, plical beneath first discal; an obtusely angulated subterminal series of indistinct short interneural dark-fuscous dashes: cilia rosy mixed with light grey. Hindwings light grey; cilia light rosy.

Takapuna, Auckland, January; one example. Next to *liochroa*, which, however, has ochreous-whitish hindwings.

Copromorphidae.

Isonomeutis restincta n. sp.

♀. 12 mm. Head brownish, sides of crown sprinkled with whitish. Palpi brownish sprinkled with dark fuscous, towards base beneath and on upper edge sprinkled with whitish. Thorax brownish. Abdomen rather dark fuscous, mixed laterally with white and on edges of two basal segments. Forewings elongate, not dilated posteriorly, costa gently arched, apex obtuse, termen very obliquely rounded; whity-brownish, irregularly and coarsely sprinkled with dark fuscous; markings formed by suffused dark-fuscous irroration; a streak along basal $\frac{2}{5}$ of costa; a moderate median fascia angulated in middle, posterior edge of angulation with a stronger dark-fuscous mark: cilia pale-brownish, basal third sprinkled with whitish and marked with well-defined spots of dark-fuscous irroration. Hindwings 6 absent; pale-brownish speckled with fuscous; a transverse whitish spot on tornus, preceded and followed by dark-fuscous suffusion: cilia pale-brownish, with darker subbasal line, round tornus mixed at base with whitish and dark fuscous.

Kaeo, north of Auckland, January; one example. Distinct from *amauropa* by forewings not dilated posteriorly, and vein 6 of hindwings absent. Having carefully reconsidered this curious genus, I am confirmed in my latest view that it is correctly referred to the Copromorphidae, and also think there is some slight indication of affinity with the Orneodidae (not found in New Zealånd), which are derived from the Copromorphidae.

HELIODINIDAE.

Stathmopoda coracodes n. sp.

♂. 13 mm. Head and thorax shining pale ochreous with violet-grey reflections, face pearly-whitish. Palpi whitish. Posterior tibiae densely clothed with rough grey hair-scales above and beneath, bristle-tuft at apex of first joint of tarsi rather large. Forewings very narrow, widest near base, pointed; rather dark violet-ashy-grey, dorsal area somewhat paler and bronzy-tinged; an elongate cloudy whitish dot below fold at $\frac{1}{4}$; a cloudy whitish dot towards termen at $\frac{4}{5}$ of wing: cilia grey. Hindwings dark grey; cilia grey.

Picton, December; one example. The posterior tibiae are more densely and roughly clothed than in *skelloni;* it is the darkest New Zealand species.

Stathmopoda mysteriastis Meyr.

I consider from the description that *seminuda* Philp. is a synonym of this.

COSMOPTERYGIDAE.

Batrachedra psathyra Meyr.

A fine pair (♂♀), sent by Mr. Hudson from Wellington, have the stigmata represented by elongate ochreous spots accompanied by some black scales, and a row of similar less-elongate spots along posterior half of costa, but am unable to separate them from others passing gradually to the less-developed type of marking.

ELACHISTIDAE.

Elachista ochroleuca n. sp.

♂. 10 mm. Head, palpi, thorax, and abdomen white. Forewings narrowly elongate-lanceolate, apex produced, acute; 4 and 8 absent; ochreous-white; an ochreous dot on fold towards extremity: cilia white. Hindwings linear-lanceolate; 4 absent; grey-whitish: cilia whitish.

Mount Aurum, 3,000 ft., amongst tussock-grass, January; one specimen.

GRACILARIADAE.

Acrocercops cyanospila Meyr.

A fine example sent by Mr. Hudson shows a projection of scattered black scales on dorsum of forewings about $\frac{1}{4}$, probably very easily lost, as it does not appear distinctly in any of my good series; two or three Indian allied species of the genus also have dorsal scale-projections.

Parectopa aellomacha Meyr.

I have no hesitation in affirming that the forms described by Mr. Watt in *Trans. N.Z. Inst.*, vol. 52, pp. 449–60, under the awkward names of *panacitorsens*, *panacivermiforma*, *panacicorticis*, and *panacifinens* are indistinguishable from this species, and these names can only be regarded as synonyms, the differences in larval habit (on the same food-plant) being merely varietal.

PLUTELLIDAE.

Cadmogenes n. g.

Head with appressed scales, side-tufts somewhat raised; ocelli posterior; tongue developed. Antennae $\frac{4}{5}$, basal joint elongate, without pecten.

Labial palpi long, recurved, second joint reaching base of antennae, thickened with appressed scales, terminal joint shorter than second, scaled, pointed. Maxillary palpi obsolete. Posterior tibiae smooth-scaled. Forewings 2 from angle, curved, 6–8 straight, slightly approximated towards base, 7 to costa, 9 and 10 somewhat approximated at base, 11 from middle. Hindwings 1, elongate-oblong-ovate, cilia $\frac{2}{3}$; 2 from rather near angle, 3 from angle, 4 rather approximated to 3 towards base, 5 parallel, transverse vein inwards-oblique from 4 to 5, 6 and 7 rather approximated towards base.

Belongs to group of *Orthenches*, from which genus it differs by terminal joint of labial palpi shorter than second, absence of maxillary palpi, and costal termination of vein 7 of forewings. This interesting form suggests some affinity with *Depressaria* and *Cryptolechia*, and may indicate the origin of the Oecophoridae from the Plutellidae, in which case it would be of high phylogenetic importance.

Cadmogenes literata n. sp.

♀. 15–17 mm. Head and thorax dull rosy or purple-fuscous. Palpi rosy irrorated with dark fuscous, tip whitish. Abdomen light-greyish. Forewings elongate, costa gently arched, apex obtuse-pointed, very slightly prominent, termen rounded, rather strongly oblique; dull crimson suffusedly speckled with dark grey and irregularly marbled and strigulated with pale ochreous-yellowish, or purple-fuscous obscurely dotted and strigulated with whitish; discal stigmata represented by irregular transverse-linear sometimes interrupted white partially dark-edged marks: cilia light rosy or violet-grey. Hindwings pale grey; cilia whitish-grey, with very faint rosy or purple tinge.

Silverstream (Upper Hutt) and Auckland, in January; two examples. These differ considerably in tone, but are certainly the same species.

Orthenches porphyritis Meyr.

I now regard *cuprea* Meyr. as only a variety of this; the species is extremely variable in markings and colouring; in some forms it displays all the colours of the rainbow, and is a beautiful insect. Mr. Hudson has bred it from *Phyllocladus alpinus*.

LYONETIADAE.

Erechthias indicans n. sp.

♀. 9 mm. Head white, sides of crown brown. Palpi fuscous, tip white. Thorax brown, with white dorsal stripe. Abdomen whitish. Forewings elongate-lanceolate, apex produced; brown irrorated with dark fuscous; an irregular white median stripe from base to $\frac{3}{5}$, broadest towards its middle, apex pointed; a narrow white dorsal stripe from base to tornus; rather thick irregular very oblique white streaks from costa at middle and $\frac{3}{4}$ almost to termen; a small round black apical spot preceded by a triangular white spot on costa: cilia whitish, round apex a median line of dark-fuscous points, a short subbasal similar line beneath apex, and one at base along termen. Hindwings and cilia whitish.

Wellington, January; one example. Near *exospila*, but smaller and darker, and distinct by the white dorsal stripe.

TINEIDAE.

Narycia Steph.

Head shortly rough-haired. Antennae $\frac{1}{2}-\frac{3}{5}$, in ♂ ciliated. Labial palpi rather short, loosely scaled. Maxillary palpi obsolete. Forewings 7 and 8 stalked or coincident, 7 to apex or termen. Hindwings 1, elongate-ovate; 2–7 nearly parallel.

Largely represented in Australia, and also occurs widely in India and Africa, but not previously noticed from New Zealand. The larvae usually feed in portable cases on lichens.

Narycia petrodoxa n. sp.

♀. 21 mm. Head light greyish-ochreous, face and a spot on crown dark fuscous. Palpi dark fuscous. Thorax pale greyish-ochreous marked with dark fuscous (partly defaced). Abdomen rather dark grey. Forewings elongate, posteriorly slightly dilated, costa gently arched, apex obtuse-pointed, termen slightly rounded, rather strongly oblique: 7 and 8 stalked, 7 to termen; pale greyish-ochreous, with some scattered coarse dark-fuscous strigulae; markings dark purplish-fuscous; three small irregular spots on anterior half of costa; a transverse spot on midddle of costa, connected by irregular or incomplete arms with quadrate spots on dorsum in middle and before tornus; three narrow transverse spots on posterior half of costa, a larger transverse spot from termen below middle: cilia rather dark purplish-fuscous. Hindwings dark grey; cilia grey.

Otira Gorge, 2,500 ft., in hot sunshine, December; one example. Quite of Australian type, but still very distinct from any species known to me.

MICROPTERYGIDAE.

Sabatinca passalota n. sp.

♂. 10 mm. Head and thorax golden-ochreous. Antennae dark fuscous, base ochreous. Abdomen dark fuscous. Forewings ovate-lanceolate, pointed nearly from middle; pale shining ochreous mostly suffused with coppery-golden; dark purple-grey elongate dots in disc at $\frac{2}{5}$ and middle, and a small elongate spot beneath and partly anterior to first; an almost marginal series of large dark purple-grey dots round posterior $\frac{2}{5}$ of costa and termen to an elongate mark on dorsum before middle of wing; some irregular whitish marginal spots adjoining these, a larger transverse one from costa at $\frac{3}{5}$: cilia pale golden-ochreous. Hindwings dark purple-grey; cilia pale ochreous tinged with grey towards base, on dorsum purplish-grey.

Bold Peak, Lake Wakatipu, 3,000 ft., amongst moss, January; one example. Forewings more long-pointed than in *chrysargyra*.

Micropardalis aurella Huds.

Described as *Sabatinca*, but is by neuration a true *Micropardalis*. The males of this species and of *M. doroxena* (of which I have also received additional examples from Mr. Hudson) agree also in having very large and curious genital valves of similar character, differing from those of any *Sabatinca*. The labial palpi, though short, are more developed in *doroxena* ♂ than in ♀, and the long maxillary palpi are also more largely developed. In *aurella* ♂ the labial palpi are very short, but perceptible.

Art. 17.—*A Monograph of the Psocoptera, or Copeognatha, of New Zealand.*

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Plate 18.

Introduction.

The Psocoptera, or Copeognatha, are a somewhat small but remarkably distinct and well-defined order of insects, having no very close affinities with any other group. With the exception of a single family of comparatively large forms, the Thyrsophoridae, confined to South America, the order contains only small insects, ranging from little more than 1 mm. long (wingless forms) to forms having an expanse of wing up to about ½ in. They are for the most part beneficial insects, feeding upon fungi, lichens, and algae, though some gnaw the outer bark of trees, and two genera at least have become world-wide pests of houses—the notorious "book-lice" (*Troctes* and *Atropos*).

Morphologically, the order is distinguished by some remarkable characters in the form of the head, mouth-parts, thorax, and wings. These may be briefly discussed here.

In the head, the epicranium (or vertex) is divided into two parts by a longitudinal suture—a primitive character not to be found in any other order of winged insects. A wide V-shaped suture divides the epicranium from the frons. The three ocelli, when present (as they usually are), lie close in at the three angles formed by the meeting of this frontal suture with the median vertical suture. The median ocellus lies on the frons, in the angle of the V, while the two lateral ocelli lie on the epicranium, one on each side of the median vertical suture. The clypeus is high and very convex, almost bulbous, and generally striated in a complicated manner; below it there is a smaller piece, lying above the labrum, which is called the "clypeolus." It will be clear that the clypeus really corresponds with the postclypeus of the Odonata, while the clypeolus corresponds with the anteclypeus of that order.

In the mouth-parts, the mandibles are interesting because of their distinct asymmetry, the teeth of one fitting into the clefts between those of the other. Each mandible carries, besides teeth, a corrugated grinding or chewing plate; and these also are of different shape in right and left mandibles. The maxillae are divided into two very distinct parts by means of the separation of a long maxillary chisel, supposed to represent the lacinia. This remarkable organ, which is without parallel in the Insecta, and from which the name Copeognatha ("chisel-jawed") is taken, is a long, hard rod, with a sharp and peculiarly-formed end, reminding one of some of the more complex of a set of carving-chisels. These chisels can be extruded from the mouth to a considerable distance, and are used

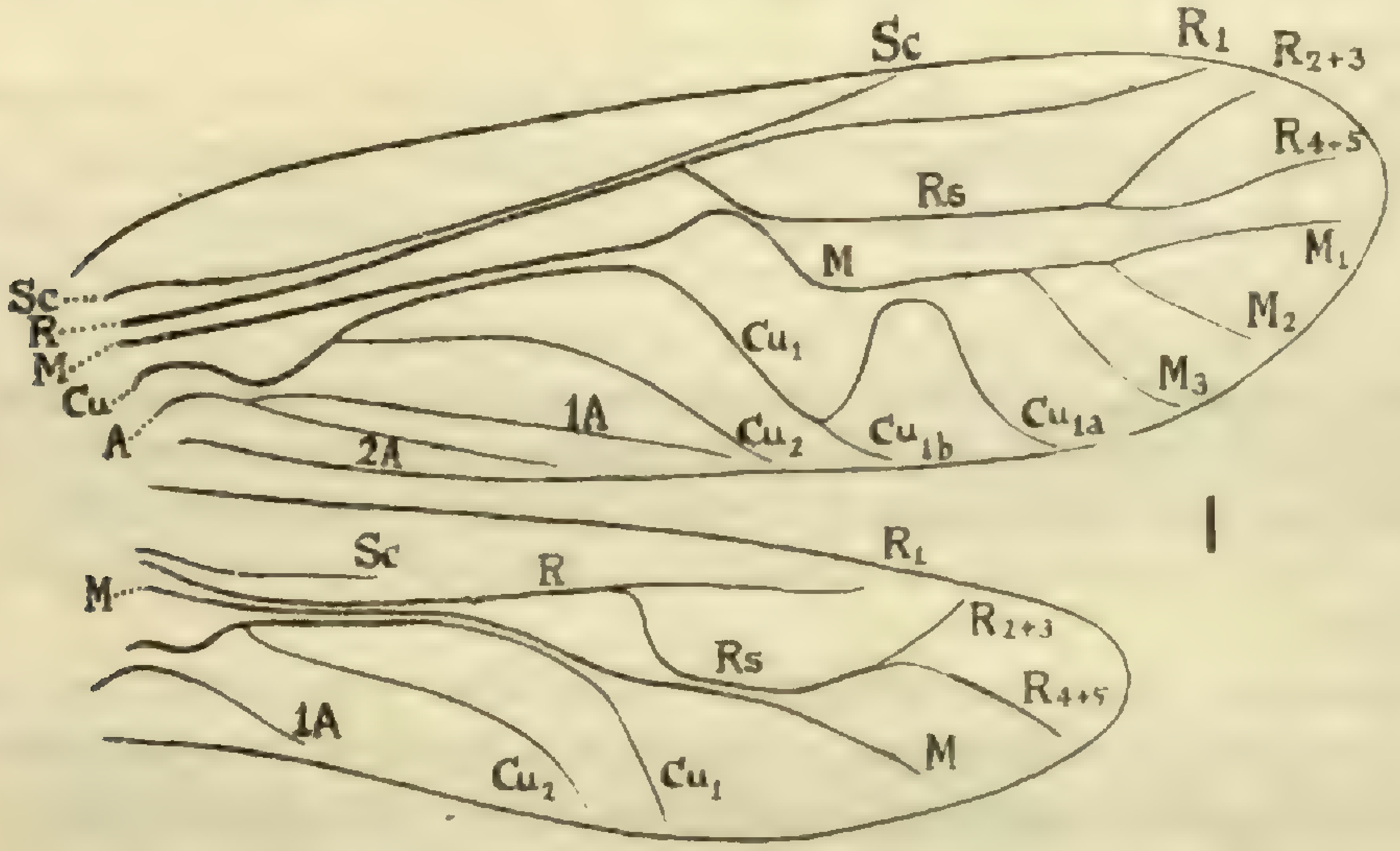
by the insects to cut away pieces of the mycelia of fungi, or to gouge out small portions of the bark of trees. The rest of the maxilla is not remarkable, the galea being normal and the palp four-jointed. The hypopharynx is trilobed. The labium is very short, with paired inner lobes and single-jointed palps.

As regards the thorax, the prothorax is small and very little developed in most of the winged forms, though it may be of comparatively large size in some of the small wingless forms. The mesothorax is nearly always the largest segment. The mesonotum is divided by sutures into a triangular anteriorly-placed piece, called the "antedorsum," a large middle piece, called the "dorsum," divided into two parts by a median longitudinal suture, and a posteriorly-placed post-dorsum, which carries the scutellum in its middle, and two narrow crests laterally, known as the "cristae scutelli." The metathorax is similar in structure to the mesothorax, but much smaller.

The legs show little specialization. The tibia usually carries one or two very small apical movable spurs. . The tarsi are either two- or three-jointed, the basal joint often carrying a complex comb (text-figs. 2, *b*, *c*, ; 13, *b*), while the distal joint ends in two claws and an empodium.

The wings are held in a roof-like manner over the body. Because of the general shape of the insect, its appearance, viewed from above when the wings are closed, offers a suggestion of the shape of a porpoise. Hence the generic name *Psocus* (Gr. = a porpoise), from which the ordinal name Psocoptera is derived. The forewings are always larger and more completely veined than the hind. The type of venation is quite unique amongst insects, permitting an insect of this order to be recognized at first sight by the venational scheme alone. In many cases the whole of the venation is formed from the main veins, and in no case are there present more than one or two cross-veins at the most. The specializations present in the wing-venation are best understood by comparing the tracheation of the larval wing with the venation of the imago. For this purpose we must compare text-figs. 1 and 2, *a*. It will then be seen that, in the forewing, Sc and R run close together, usually completely fused, and only separating distally, Sc stopping short first, and forming the basal boundary of the pterostigma, while R_1 runs on, forming all of its posterior and distal boundaries. Normally the pterostigma is much enlarged distally, owing to the waviness of R_1 forming a distal convexity. Rs comes off from R near the middle of the wing, and often fuses at a point, or for a short distance, with M before passing on to divide into its two end branches, R_{2+3} and R_{4+5}. M descends from R close to the base, and at once fuses with Cu_1 very close to the point of origin of that vein from the main stem of Cu. This fusion continues nearly to the level of the origin of Rs, and then M and Cu_1 diverge sharply, the former running to touch or join Rs, while the latter descends obliquely towards the posterior wing-margin. Distally, M gives off normally three branches, very rarely four, five, or even eight. Cu_1, just before reaching the margin, usually divides into two. Of these, the more basal branch, Cu_{1b}, is generally short, and runs directly to the margin. But the more distal, Cu_{1a}, arches up again away from the margin, and forms a more or less well-marked cubital loop, enclosing a special area known as the "areola postica." This loop sometimes becomes connected with M above it by a cross-vein, or it may actually itself touch M, or even fuse with it for a greater or less distance, in which case its distal portion will appear as if it were an extra branch of M.

The clavus, or anal area of the wing, is separated from the rest by the concave vein Cu_2, which leaves the main stem of Cu near the base, and runs obliquely, and generally almost straight, to about the middle of the



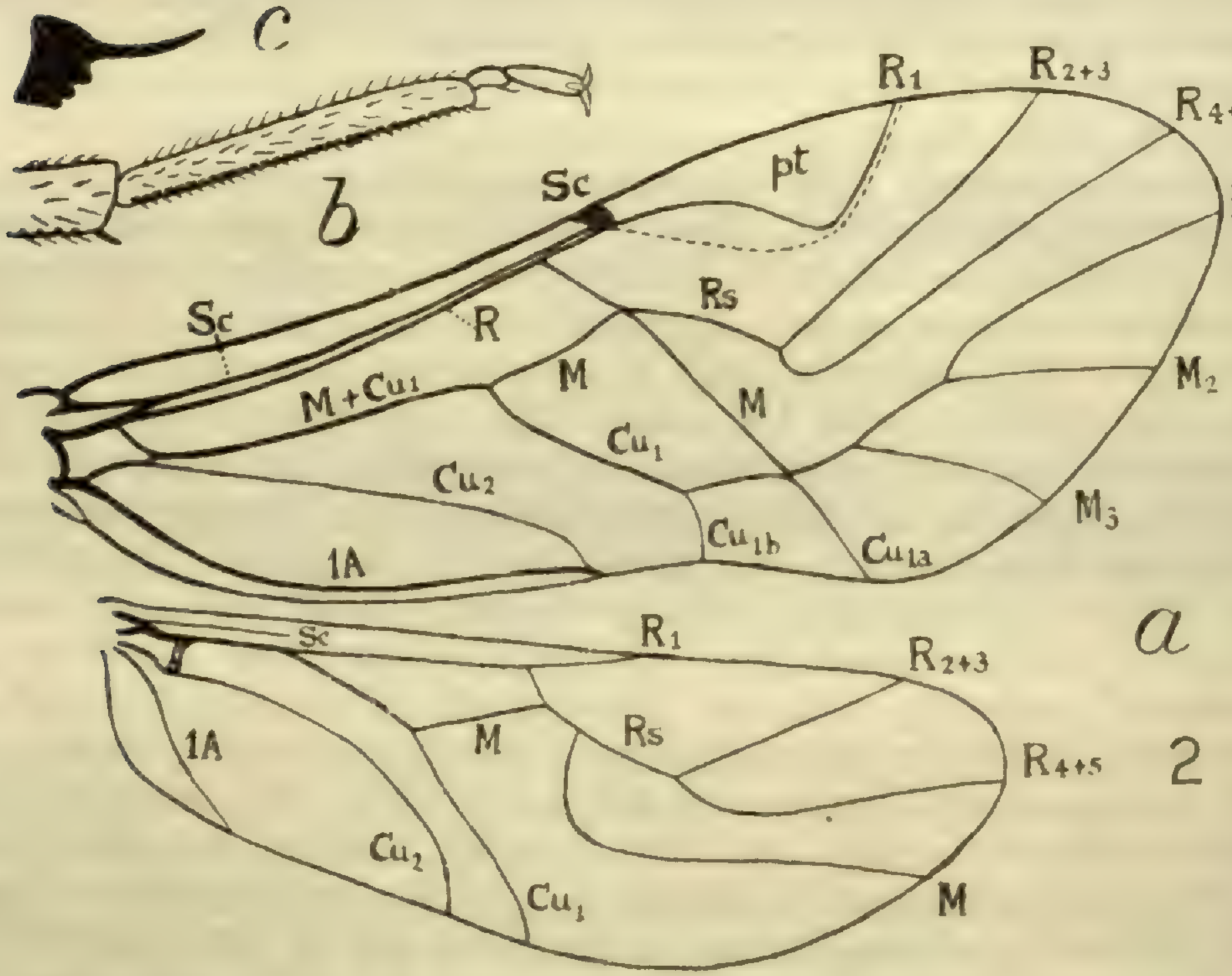


FIG. 1.—Tracheation of last larval instar in an undescribed Australian species of *Psocus*. × 54. 1A, anal vein; Cu, cubitus; Cu_1, its anterior branch, dividing into Cu_{1a}, and Cu_{1b} in forewing, the former making the *cubital loop*; Cu_2, its posterior branch, bounding the *clavus* anteriorly; M, media; M_1, M_2, M_3, M_4, its branches; *pt*, pterostigma; R, radius; R_1, its main stem, forming in forewing the posterior border of pterostigma; Rs, radial sector, dividing into R_{2+3} and R_{4+5}; Sc, subcosta, its free end in forewing forming the basal side of the pterostigma.

FIG. 2.—*a*. Venation of *Myopsocus novae-zealandiae* Kolbe, ♂; × 24. *b*. Three-jointed hind tarsus of same, showing the comb on the basal joint; × 24. *c*. A single tooth from the same comb; × 232.

posterior margin of the wing, thus cutting off the clavus as a rather narrow area with more or less sharp distal angle. Previous authors, in dealing with this vein, have called it 1A, following the mistake made by Comstock

and Needham. Having examined the tracheation of the wings in the last two instars of an Australian species of *Psocus*, I have been able to prove that this vein is from the very first a branch of Cu. This result brings the Psocoptera into line with all other insects, in which it is now known universally that the vena dividens, separating the clavus from the rest of the wing, is formed by Cu_2. The only anal vein in the Psocoptera is the strongly convex 1A, running more or less close to the wing-margin.

In the hindwing the venation is considerably simplified. Sc is absent or a mere remnant, and there is no true pterostigma. Rs has two branches, as in the forewing, but M remains usually unbranched, though it may possess two branches in a few very archaic types. Basally, R, M, and Cu_1 become united for a space, and more distally Rs and M again unite for a short distance. There is no cubital loop, Cu_1 remaining always unbranched and running obliquely to near the middle of the posterior margin. Cu_2 is unbranched, and 1A usually very short.

The question of the affinity of the Psocoptera with other orders scarcely concerns us here, but it may be mentioned that they appear to be most closely related to the newly discovered order Zoraptera, which again shows relationship with the Isoptera. In other directions the Psocoptera show certain affinities with the Thysanoptera, Hemiptera, and Hymenoptera. The two parasitic orders Mallophaga and Anoplura appear undoubtedly to have been derived from some ancient wingless Psocoid type similar to the Atropidae, and it is worthy of note that wingless Psocoptera are even known at the present day to live upon mammals.

Little is known of the life-histories of the Psocoptera. Their eggs are laid in flat masses of twenty or more together, on leaves or under bark, and are covered with a fine protective web, spun from the mouth of the insect in a manner similar to that of the lepidopterous caterpillar. The young resemble the imago, except for the absence of wings; they have always two-jointed tarsi. The number of instars is not large, probably four only, the wing-buds appearing at the second instar. In the last instar the size of the body may appear even greater than that of the imago; but it shrinks somewhat just before the metamorphosis, which is accomplished with ease and celerity.

CLASSIFICATION.

The order is usually divided into two suborders on the number of joints in the tarsi, as follows:—

Tarsi three-jointed in imago, two-jointed in larva	Suborder TRIMERA.
Tarsi two-jointed in both imago and larva	Suborder DIMERA.

For taxonomic purposes this is a very convenient division, and it will be adopted here. I wish, however, to state that it seems quite clear that this subdivision does not represent the original dichotomy of the order, but merely separates the three most highly specialized families from all the rest. The more archaic representatives of the order are so rare, and so little is known about them, that much more work remains to be done before we shall be in a position to offer a classification of the order which truly represents its main lines of evolution.

The Trimena contain seven families—the Amphientomidae, Lepidopsocidae, Psoquillidae, Atropidae, Troctidae, Mesopsocidae, and Myopsocidae. Of these, only five have so far been found in New Zealand—viz., the Lepidopsocidae, Atropidae, and Troctidae (introduced species only), Mesopsocidae, and Myopsocidae.

The Dimera contain only three families—the Caeciliidae, Psocidae, and Thyrsophoridae. Only the first of these three is known in New Zealand. It is worthy of remark that, though the Psocidae are the dominant family in the Northern Hemisphere, and are abundant in Australia, not a single introduced species of this family has so far been noted for New Zealand.

The only species at present recorded for New Zealand in the order Psocoptera is the large and handsome mottled brown species *Myopsocus novae-zealandiae* Kolbe, quite a conspicuous insect, and very common in some localities. The introduced "book-lice," *Troctes divinatorius* (Müller) and *Atropos pulsatoria* (Linn.), are also, of course, exceedingly common in houses here as elsewhere, but there does not appear to be any published record of them for New Zealand. In the native bush small species of Psocoptera are by no means uncommon, and at least two native species have spread to orchards and gardens, where they may be found in great abundance, feeding upon fungoid growths. As a result of two or three months' collecting in a few localities only I have been able to bring to light a considerable number of new species. Specimens have also been received from Messrs. H. Hamilton and J. G. Myers, of Wellington; W. G. Howes, of Dunedin; and A. Philpott, of Nelson (including some collected by him around Invercargill). To all of these gentlemen I offer my sincere thanks for their help, and I hope that the publication of this paper may stimulate collecting in this order, and help to bring to light many more new species which, I feel sure, must still exist in many parts of these Islands. I also desire to thank Mr. W. C. Davies, Curator of the Cawthron Institute, for the excellent photograph from which Plate 18 has been prepared, and Mr. Philpott, Assistant Entomologist, for arranging the types for that purpose.

In the keys which follow I propose to give only those families and genera found in New Zealand, with the addition of the family Psocidae, so that introduced species belonging to that family may be recognized if any happen to be discovered later on.

Key to the Families of Psocoptera found in New Zealand, with the Addition of the Psocidae.

1	Tarsi three-jointed in imago, two-jointed in larva. Suborder Trimera	2
	Tarsi two-jointed in both imago and larva. Suborder Dimera	6
2	Meso- and meta-thorax completely fused together; imago absolutely without wings	Troctidae.
	Meso- and meta-thorax separate; imago only very rarely wingless	3
3	Imago wingless, or at most with only vestiges of forewings; prothorax strongly developed, larger than mesothorax ..	Atropidae.
	Imago winged, prothorax much smaller than mesothorax ..	4
4	Wings with abnormal venation; Cu_2 and 1A in forewing not ending up together; body and wings both scaly and hairy; antennae with more than 13 joints	Lepidopsocidae.
	Wings with normal venation; Cu_2 and 1A in forewing ending up together; no scales on body or wings; antennae with 13 joints	5
5	Cubital loop of forewing not touching M above it	Mesopsocidae.
	Cubital loop of forewing either just touching M or fusing with M for a short distance	Myopsocidae.
6	Cubital loop of forewing absent, or, if present, not touching or connected with M above it	Caeciliidae.
	Cubital loop of forewing present, either joined to M above it by a cross-vein, or just touching M, or fused with M for a greater or less distance	Psocidae

DESCRIPTIONS OF THE GENERA AND SPECIES FOUND IN NEW ZEALAND.

Family ATROPIDAE.

This family may at once be recognized by the vestigial condition of the wings, the forewings being mere flaps, of small size, and without any true venation, while the hindwings are entirely absent. In some species it would appear that the forewings also are either absent or else commonly shed or broken off (vide *Lepinotus*, infra). They may at once be distinguished from the Troctidae by the fact that the meso- and meta-thorax remain as distinct, freely movable segments, not fused together, and the tarsal claws are never furnished with internal teeth. The two genera here recorded as having been introduced into New Zealand may be distinguished as follows:—

Meso- and meta-thorax equally reduced to narrow rings, both smaller than prothorax; antennae with 15 to 17 joints; last joint of maxillary palp elongate-oval; eyes very prominent; forewings in the form of broad flaps, or sometimes absent; abdomen broad and well rounded .. .. *Lepinotus* Heyd.

Metathorax longer and wider than both prothorax and mesothorax; antennae with 26 or more joints; last joint of maxillary palp hatchet-shaped; forewings in the form of somewhat narrower flaps; abdomen oval, much longer than wide .. .. .. *Atropos* Leach.

Genus ATROPOS Leach (= *Clothilla* Westwood).

Characters as given in the key above.

Genotype.—Atropos pulsatoria (Müller).

Atropos pulsatoria (Müller). Lesser death-watch; book-louse; book-tick. (Text-fig. 3.)

Though common throughout New Zealand, this insect has never yet been recorded as occurring here. It was probably introduced from England during the early days of settlement. As this insect is frequently confused with *Troctes divinatorius* (Linn.), the other common book-tick, a figure of it is given here. In size it may reach up to 2 mm. in length. The head is large, with the epicranial, frontal, and clypeal sutures well marked. The compound eyes are large, but ocelli are absent. The antennae have 26 or more joints, of which the first two are stouter than the rest. The maxillary palpi are four-jointed, the second being the longest, and the fourth (or distal) joint somewhat flattened and hatchet-shaped. The prothorax is broader and stronger than the mesothorax, the latter being a mere ring from the sides of which the vestigial forewings are developed; these project backwards and are very hairy. The metathorax is much longer, but there are no vestiges of the hindwings. In the legs, the femora are very stoutly built, the tibiae long and slender, the tarsi three-jointed, the basal joint being longer than the other two combined; the claws are well developed, but the empodium very small; each claw carries at its base a strong tenent hair, as long as the claw itself, and notched near its tip. The abdomen is elongate-oval, with distinct but narrow lateral ridges on segments 2–7. Colour testaceous, the abdomen rather prettily marked with regularly arranged brown spots, as shown in the figure. The abdomen is much less hairy than in the next succeeding species.

Genus LEPINOTUS Heyd.

Characters as given in the key above.
Genotype.—Lepinotus inquilinus Heyd.

Lepinotus inquilinus Heyd. (Text-fig. 4.)

This species is fairly common throughout New Zealand, and does a considerable amount of damage to books, paper, museum specimens, &c. It is here shown. Mature specimens vary in size from 1 mm. to 1·5 mm. in length, and may be either pale brown, dark brown, or almost black in

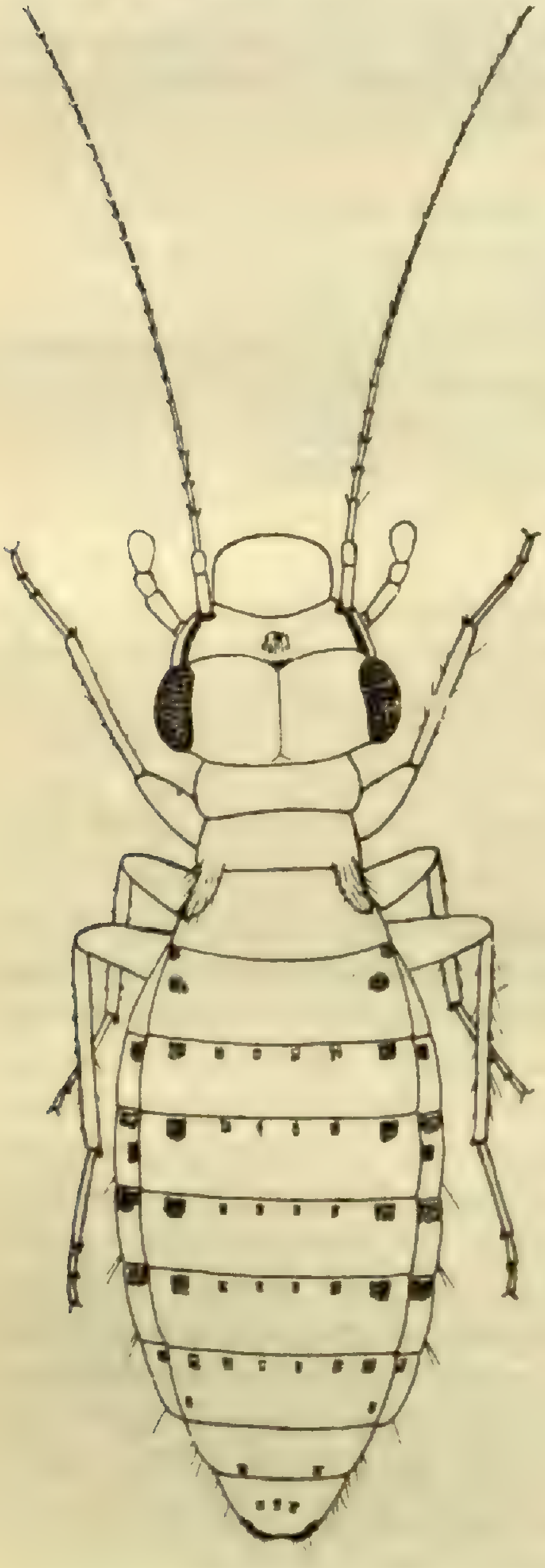


FIG. 3.—*Atropos pulsatoria* (Müller). Nelson, N.Z. × 40.

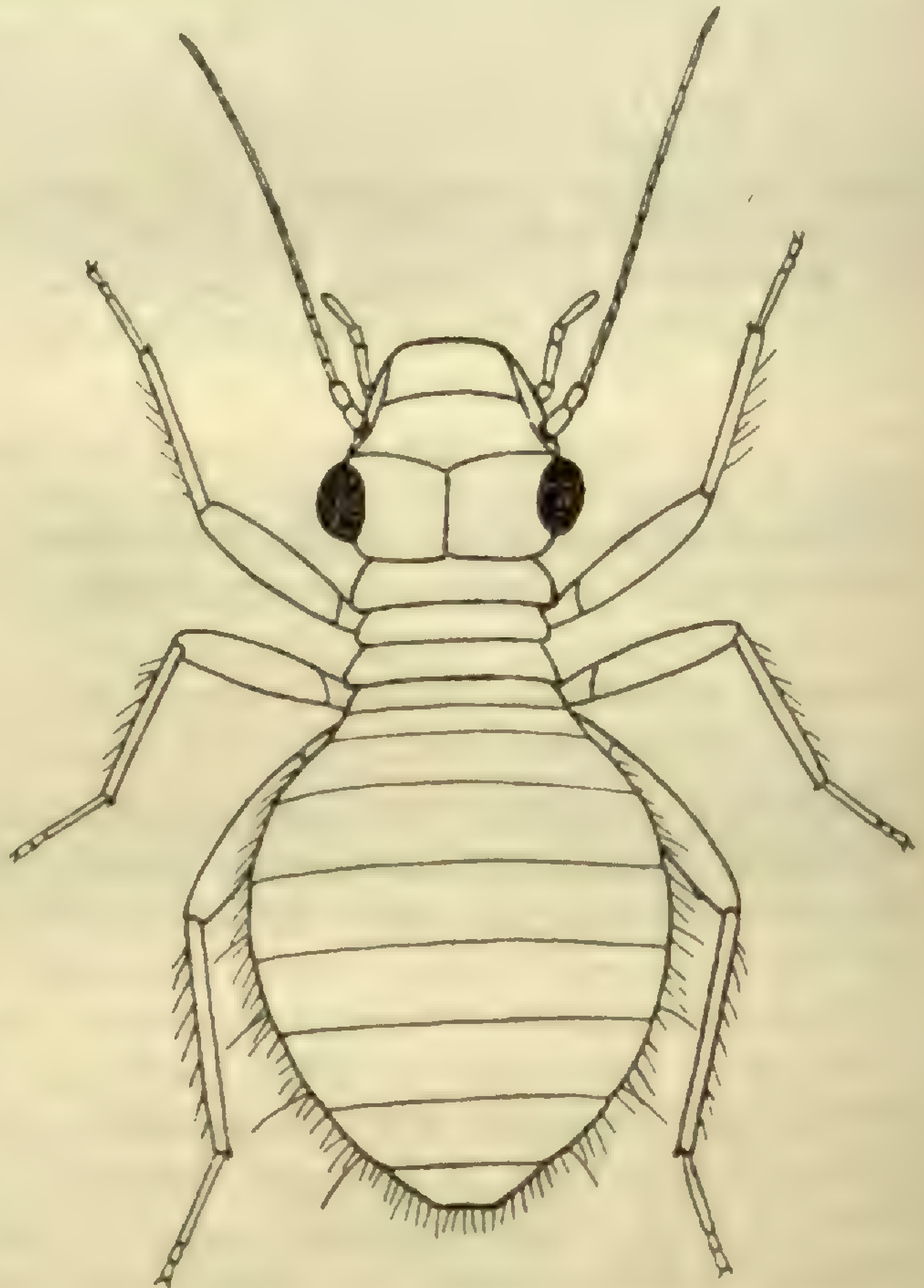


FIG. 4.—*Lepinotus inquilinus* Heyd. Wingless form. Nelson, N.Z. × 40.

colour. The head-sutures are fairly distinctly marked. The compound eyes are large and prominent, but there are no ocelli. The antennae consist of from 15 to 17 joints, of which the first two are stouter than the rest. Maxillary palpi four-jointed, the second joint a little longer than the distal one, which is elongate-oval in shape. The prothorax is well

developed, with slightly projecting lateral lobes. Meso- and meta-thorax are equally reduced to two mere rings; forewings either quite absent (possibly broken off) or present as short, broad, hairy flaps of a dark colour. The legs have stout and fairly long femora, long slender tibiae, and three-jointed tarsi, the basal joint being much longer than the other two combined. The claws are well developed, the empodia larger than in *Atropos*, but the tenent hairs weaker and shorter. The abdomen is broadly rounded, in mature females nearly as broad as long; the divisions between the segments are not quite as clearly marked as in *Atropos*. There is no colour-pattern, but an abundance of soft, delicate hairs.

The specimen figured is fully grown, but without wings. Specimens with the forewings present are, as far as my experience goes, less commonly found.

Family TROCTIDAE.

This family can at once be distinguished from all other families of the order by the complete fusion of the meso- and meta-thorax, so that the thorax at first sight appears to possess only two segments. It contains only very small, entirely wingless species. The tarsal claws carry an internal tooth before the apex.

Genus Troctes Burm.

In addition to the family characters, this genus has the head rounded, with very small eyes; the last joint of the maxillary palp is elongate-oval; the abdomen is rather long and narrow, well rounded behind, with segments 9 and 10 completely fused together.

Genotype: Troctes divinatorius (Linn.).

Troctes divinatorius (Linn.). Small book-louse; book-tick; cabinet-mite.

This species appears to be abundant everywhere in New Zealand, and is probably responsible for more damage in the aggregate to books, papers, museum specimens, &c., than the two larger species of Atropidae put together. As it is so well known, I have not figured it, but will point out that it can at once be recognized, under a moderate power of the microscope, by the family character of the fusion of the meso- and meta-thorax. In the general shape of the head, the form of the maxillary palpi, and the number of joints in the antennae it bears a general resemblance to *Lepinotus*, but can at once be distinguished from the latter by the more rounded head and the very small eyes. The abdomen is not broadly rounded as in *Lepinotus*, being much narrower, more like that of *Atropos* in shape, but much more rounded posteriorly. A microscopic examination of the tarsal claws will reveal the presence of the small tooth placed internally before the apex; this tooth is absent in all Atropidae. A further character is the armature of the hind femora, along their outer edge, with minute blunt teeth.

This species is considerably smaller than either of the two preceding ones, mature individuals measuring only 1 mm. long or a little over. They are mostly of a pale-testaceous colour, not unlike that of *Atropos pulsatoria*, but without any pattern whatever. Specimens can be obtained at almost any time of the year, simply by leaving some torn pieces of paper, dead leaves, sweepings, or other debris in a wooden box or a tin for a few weeks.

Family LEPIDOPSOCIDAE.

Antennae with considerably more than 13 joints. Maxillary palpi with the distal joint hatchet-shaped. Ocelli present, widely separated from one another. Body and wings both hairy and scaly, the scales pointed. Wings more or less pointed, the venation not of the normal Psocoid type; forewing with Cu_2 and 1A not ending together.

This family may be conveniently divided into two subfamilies, according to the following key:—

Antennae with 20–25 joints; hindwings with a very narrow closed cell; scales symmetrical	Subfamily PERIENTOMINAE.
Antennae with 26–47 joints; hindwings without a closed cell; scales asymmetrical	Subfamily LEPIDOPSOCINAE.

Only the latter subfamily is known in New Zealand.

Subfamily LEPIDOPSOCINAE.

Genus OXYPSOCUS n. g.

Head very hairy; thorax and abdomen carrying both hairs and scales. Antennae with about 28 joints, the first two swollen, the rest slender and slightly swollen at bases and tips. Maxillary palpi hairy. Wings sharply pointed, with a fringe of long hairs, especially long on posterior border of hindwing. Forewing excessively hairy and also scaly, the scales long and cultriform in shape. Hindwing without scales, and with few hairs except those forming the fringe. Venation very complete, Rs having two branches in each wing, M with three branches in fore and two in hind. In the forewing the costal border up to the pterostigma is strongly chitinized, and carries abundant scales and hairs. Pterostigma triangular, the free end of Sc, forming its basal side, being of considerable length. There is a narrow cell in basal third of forewing, closed distally by a small basal piece of Rs descending from R and fusing with M. Cu_1 leaves $M + Cu_1$ at about two-thirds along posterior side of this cell, and soon afterwards divides dichotomously into Cu_{1a} and Cu_{1b}. Cu_2 is a straight vein, weakly formed basally. 1A runs below it slightly divergingly, so that these two veins end up a considerable distance apart. Anal angle of clavus well marked, obtuse. In the hindwing all the veins except only Cu_2 and 1A are fused together basally. From this main stem Sc comes off very close to the base, and runs slantingly to end up at about one-third along the costal border. R_1 comes off at about one-third of the wing-length, and Cu_1, which is unbranched, just before it. M_3 and M_{1+2} come off close to half-way and Rs divides somewhat beyond half-way into R_{2+3} and R_{4+5}, of which the latter runs to the apex. Cu_2 and 1A arise close together, but diverge considerably.

Genotype.—*Oxypsocus hamiltoni* n. sp. (New Zealand).

This genus is evidently a very archaic one, and appears to have its closest relative in *Echmepteryx* Aaron, from which it differs in the much more pointed wings, in the presence of a definite Sc in both wings, in the strongly chitinized costal area, in the much shorter and narrower closed cell of the forewing, and in the longer and narrower apical forkings of the veins. In its sharply pointed wings it resembles *Echinopsocus* End., but this latter genus has a very reduced venation and no closed cell in the forewing.

Oxypsocus hamiltoni n. sp. (Plate 18, fig. 1; text-figs. 5, 6.)

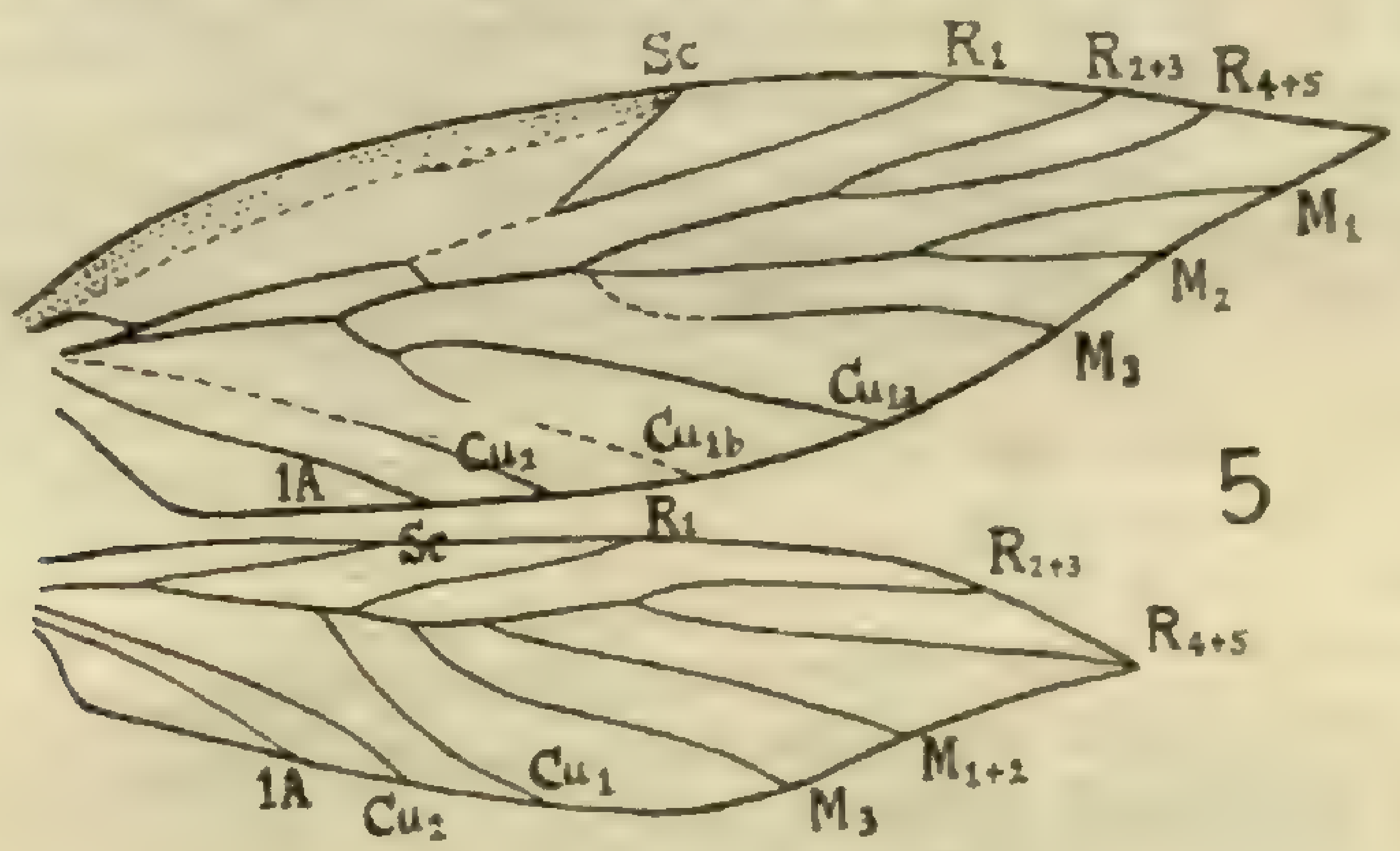
Forewing, 3 mm.; expanse of wings, 6·8 mm.

Head covered with golden-brown hairs and with a smaller number of black ones. Epicranium light brown, with two large squarish patches of dark brown between eyes, and three smaller patches covering the ocelli, which are black. Eyes and frons mottled with light and dark brown. Antennae brown, a pale ring on second joint; each joint from the third outwards with a whorl of several stiff hairs as long as the joint itself; the total number of joints is about 28. Clypeus very dark brown. Labrum pale brown in centre, bordered with dark brown.

Maxillary palpi medium brown.

Thorax dark shining brown with golden-brown hairs and darker scales. Legs dark brown banded with pale brown; tibiae with long stiff hairs.

Abdomen dark brown with paler brown hairs and scales.



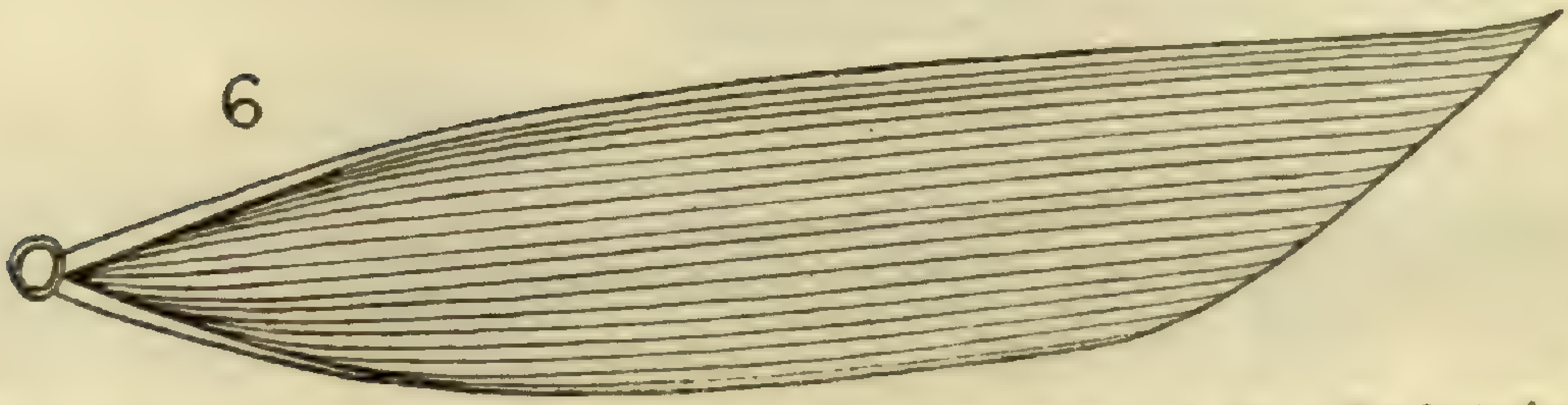


FIG. 5.—*Oxypsocus hamiltoni* n. g. et sp., type. Venation. × 25. (For lettering see fig. 1.)

FIG. 6.—*Oxypsocus hamiltoni* n. g. et sp., type. A single scale from forewing. × 940.

Wings: Forewings suffused with brown; hairs golden-brown, scales dark brown but paler near their bases. One of these scales is shown in text-fig. 6; it measures 0·12 mm. in length, and is of a peculiar cultriform shape, the sharply pointed apex being in line with one side of the scale, while the other side slopes off obliquely for the last quarter of its length; there are about 18 very distinct longitudinal striae, which remain well separated distally, but tend to run together towards the base; no cross-striolation is present. Venation of forewing mostly pale and rather indistinct in places, but the main stem of $M + Cu_1$ is dark brown. Hindwing hyaline, with dark-brown venation and greyish hairs on fringe.

Type.—Holotype in Cawthron Institute collection; also a paratype dissected and mounted on two slides, the wings separate from the rest. One set paratype in Dominion Museum collection, Wellington.

Habitat.—Masterton, N.Z. Taken by Mr. H. Hamilton, Zoologist to the Dominion Museum, Wellington, on the 28th March, 1921, while beating a bush of *Cyathodes acerosa.* The species is dedicated to its discoverer.

The finding of this remarkable archaic Psocopteron is a noteworthy event in New Zealand entomology. A species of *Echmepteryx* has been described from Western Australia, and a species of *Echinopsocus* from New Guinea; but this new genus is more archaic than either of these. It appears to occupy, within the order Psocoptera, a position closely analogous to that of the genus *Sabatinca* within the Lepidoptera, and there is also a close similarity in the venational type and in the structure of the scales. Parenthetically, it might be noted that these scales, if obtainable in sufficient numbers, would be of considerable value in testing the resolving-powers of lens-combinations for high magnifications.

Family MESOPSOCIDAE.

Antennae with 13 joints. Ocelli present. Maxillary palpi four-jointed, the last joint of normal elongate-oval shape. Tarsi three-jointed, the basal joint longer than the other two together. Venation of the normal type, the forewing with Cu_2 and 1A ending together. Cubital loop of forewing present, but not touching M above it. No scales on body or wings.

Key to the New Zealand Genera of Mesopsocidae.

1	Wings hairless and without fringe .. .. .. (Genotype, *Mesopsocus unipunctatus* Müller.)	*Mesopsocus* Kolbe.
	Wings with a fringe of hairs, the forewing with hairy veins ..	2
2	Pterostigma with a small stump-vein projecting downwards from the middle of its posterior border .. .. (Genotype, *Philotarsopsis delicatus* n. sp.)	*Philotarsopsis* n. g.
	Pterostigma normal, without any stump-vein	3
3	Forewing very broad distally, about two-fifths as broad as long; antennae with numerous whorls of hairs as long as the individual joints .. .. (Genotype, *Zelandopsocus formosellus* n. sp.)	*Zelandopsocus* n. g.
	Forewing of normal shape, about one-third as broad as long; antennae with only very short hairs .. .. .. (Genotype, *Philotarsus picicornis* [Fabr.].)	*Philotarsus* Kolbe.

Genus Philotarsus Kolbe.

Characters as given in the key above. The genus was separated from *Elipsocus* Hagen by Kolbe on the amount of fringe present in the hindwing. In *Philotarsus* the fringe of hairs is complete in this wing; in *Elipsocus* the hairs are confined to the margin around the apex. The genus is also closely allied to *Hemineura* Tetens, in which the hindwing possesses no fringe of hairs at all.

Genotype.—Philotarsus picicornis (Fabr.).

Two species of this genus have been described from Australia. The two known New Zealand species may be separated by the following key:—

Insect of stout build, veins of the forewing strongly formed; Cu_2 of forewing hairy; stigma dark; middle part of forewing irregularly clouded	*Ph. guttatus* n. sp.
Insect of slenderer build, veins of the forewing not so stoutly built; Cu_2 of forewing without hairs; stigma pale in centre, with a dark patch at each end; little or no clouding in middle part of forewing	*Ph. maculatus* n. sp.

Philotarsus maculatus n. sp. (Plate 18, fig. 2; and text-fig. 7.)

Forewing, 3 mm.; expanse of wings, 6·7 mm.

Head cream-colour, heavily spotted with dark brown on epicranium, frons, and clypeus; clypeolus unspotted; labrum black. Eyes dark brown. Antennae pale greyish-brown, ringed with cream-colour at base. Maxillary palpi pale brown, distal joint black.

Thorax brown, the divisions of the mesonotum margined with cream-colour; antedorsum cream-colour with two dark spots. Legs pale greyish, brown with darker markings, the tarsi very dark brown.

Abdomen brown with cream-coloured markings.

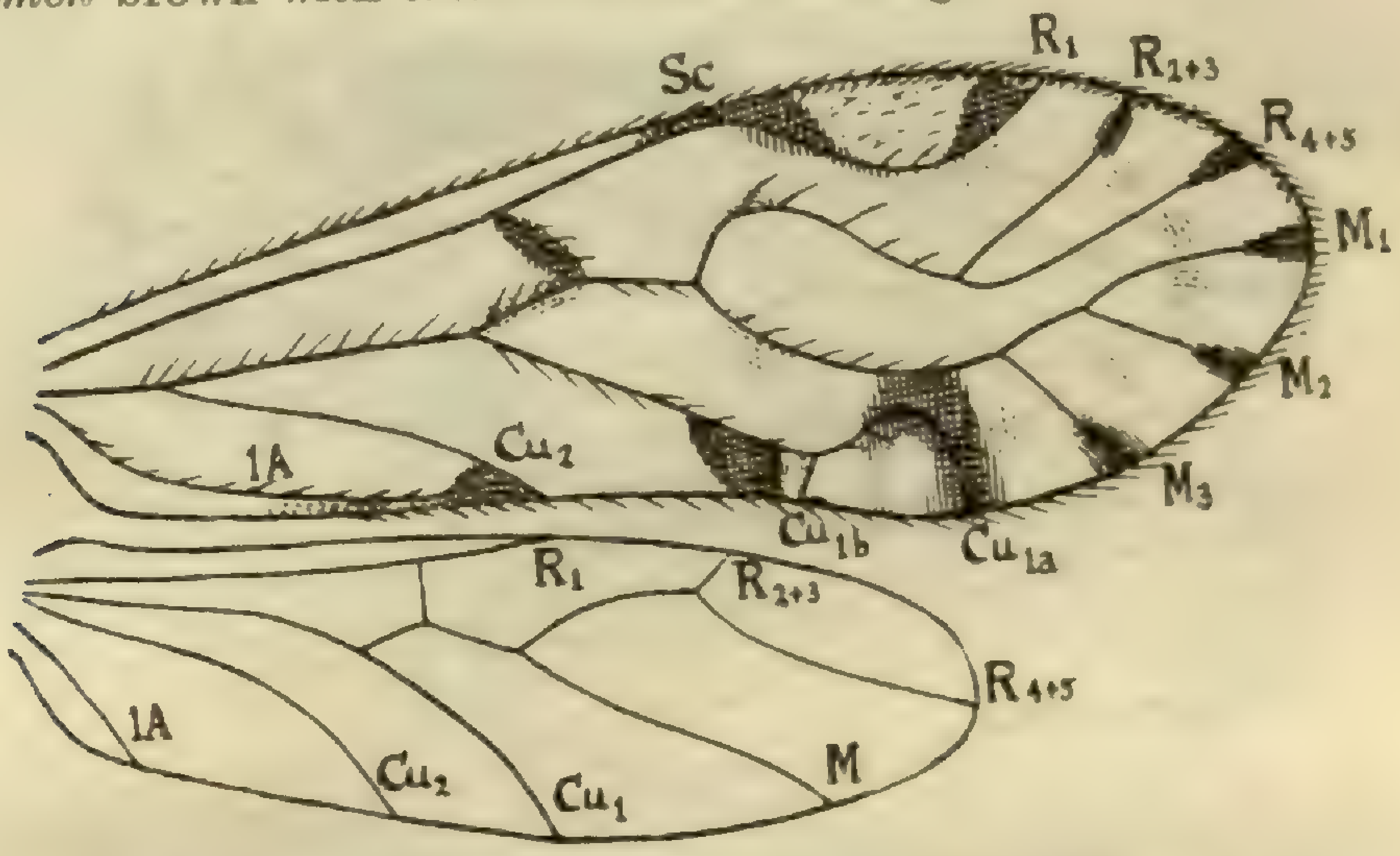


FIG. 7.—*Philotarsus maculatus* n. sp., type. Venation. × 24. (For lettering see fig. 1.)

Wings hyaline, the veins dark. Forewing marked with very dark spots at both ends of the pterostigma, at the distal end of the clavus, along the basal piece of Rs, along M just below it, between Cu_1 and the posterior margin just basad from Cu_{1b}, also more largely around the cubital loop, this patch extending up to the stem of M above it, and finally on the distal ends of all the veins from R_{2+3} to M_3. Hindwing without any markings.

Habitat.—York Bay, Wellington Harbour, N.Z. A number were taken by me while sweeping the foliage of a young native beech (*Nothofagus Menziesii*) on the 20th March, 1921.

Type.—Holotype and series of paratypes in Cawthron Institute collection, Nelson.

Philotarsus guttatus n. sp. (Text-fig. 8.)

Forewing, 3·2 mm.; expanse of wings, 7 mm.

Head.—Epicranium and frons dark brown, strongly granulated, and carrying golden-brown hairs. Antennae brown. Eyes dark brown. Clypeus brown, marked with numerous thick black striae carrying shallow pits. Clypeolus medium brown. Labrum blackish. Maxillary palpi pale brown, the distal joint blackish.

Thorax very dark brown, with golden-brown hairs. Legs brown, paler beneath.

Abdomen stout, dark brown.

Wings with very hairy margins and stout dark-brown veins; those of the forewing, including Cu_2, hairy, densely so on the basal half of the

wing. Pterostigma very hairy. Membrane of wing hyaline, blotched with dark brown as follows: On the forewing, two very dark blotches on pterostigma, one covering Sc, the other occupying most of the enlarged distal area; between them an area of paler brown, and another paler area completing the stigma distally. Irregular brown blotches also occupy the central portion of the forewing and surround the tips of the apical veins from R_{2+3} to M_3. Distal two-thirds of cubital loop also filled with dark brown. In hindwing there is a patch of dark brown at distal end of clavus.

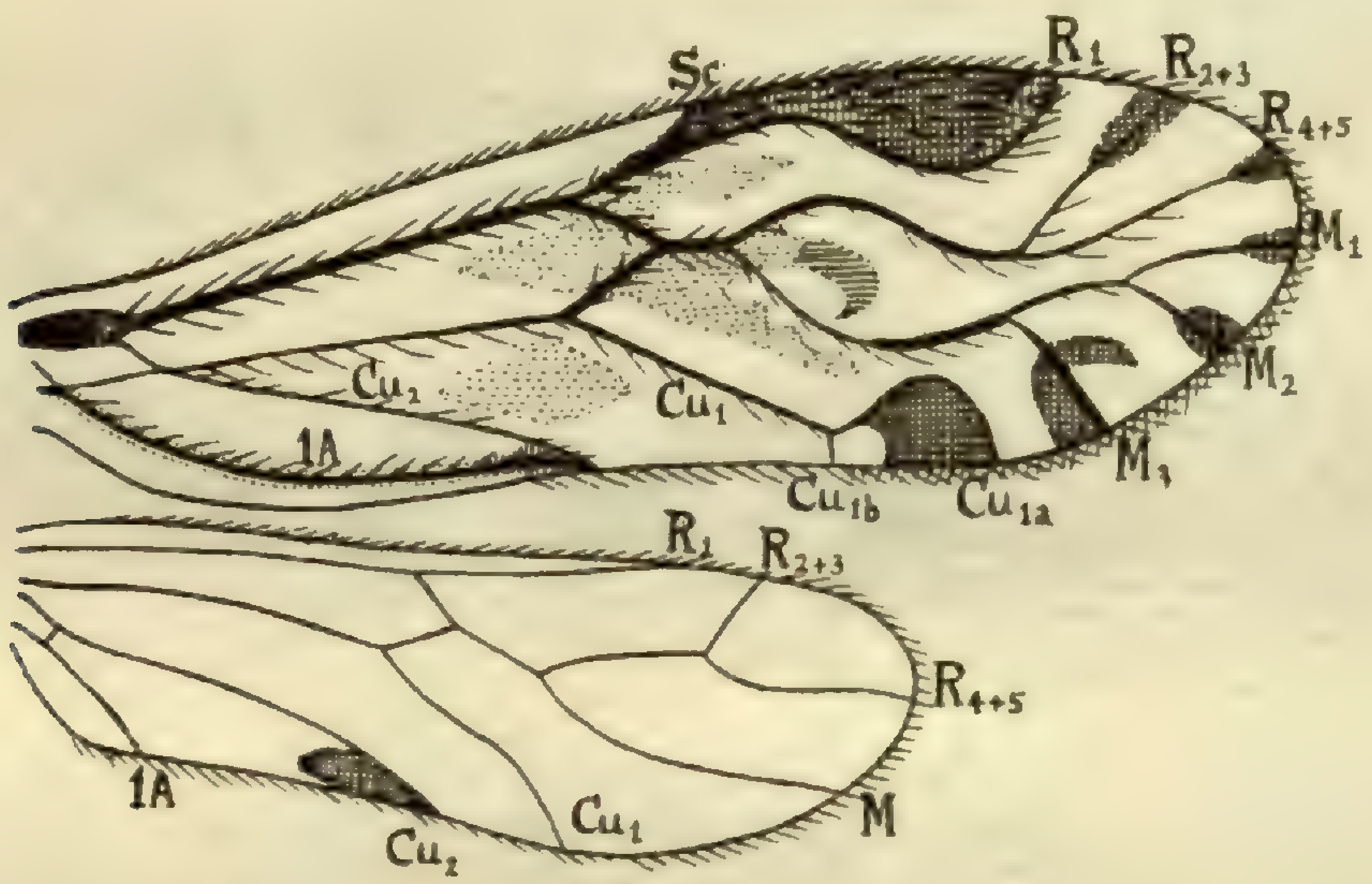


FIG. 8.—*Philotarsus guttatus* n. sp., type. Venation. × 24. (For lettering see fig. 1.)

Habitat.—Tisbury, near Invercargill, N.Z.; two specimens taken by Mr. A. Philpott in January, 1918. Masterton, N.Z.; one specimen taken by Mr. H. Hamilton, March, 1921.

Type.—Holotype (15th January, 1918) and paratype (18th January, 1918) from Tisbury, in Cawthron Institute collection, Nelson.

Genus PHILOTARSOPSIS n. g.

Characters as given in the key above. It is closely allied to *Philotarsus* Kolbe, but differs in possessing a stump-vein descending from the middle of the posterior border of the pterostigma in the forewing, and also in the narrower bases of both fore and hind wings. This genus resembles *Psilopsocus* End. in possessing the stump-vein, but differs from it in that *Psilopsocus* has absolutely hairless wings.

Genotype.—*Philotarsopsis delicatus* n. sp.

Habitat.—New Zealand only, so far is is known.

Philotarsopsis delicatus n. sp. (Text-fig. 9.)

Forewing, 3·8 mm.; expanse of wings, 8·2 mm.

Head yellowish-brown, marked with very dark brown as follows: On the epicranium, a central mark behind the ocelli in the form of two U's close together and inverted; depending from the inner margin of each eye, an inverted mark of interrogation; an oblique dark stripe running from each lateral ocellus to base of antenna on same side; on the frons, a blackish patch in front of the median ocellus. Antennae dark brown, the

two basal joints touched with paler brown. Eyes very dark brown, slightly mottled with medium brown. Ocelli large, black. Clypeus striated with dark brown or blackish, and carrying a few long slender pale hairs. Clypeolus pale brown. Labrum blackish. Maxillary palpi pale yellowish-brown, distal joint blackish.

Thorax very dark brown, touched with paler brown, and carrying long slender grey hairs. Legs dull-brownish.

Abdomen dark brown, with paler markings.

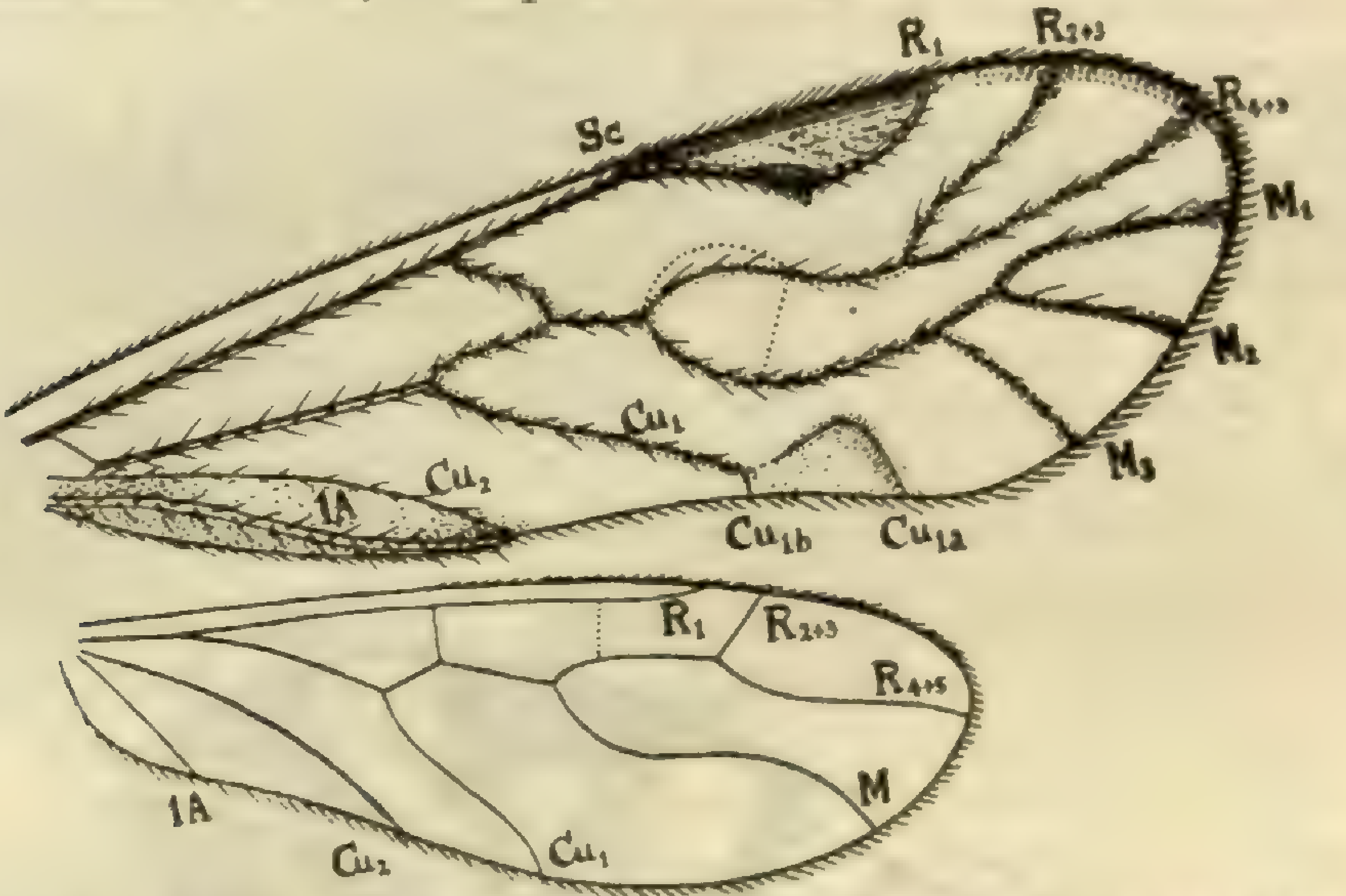


FIG. 9.—*Philotarsopsis delicatus* n. g. et sp. Venation. × 24. (For lettering see fig. 1.) The dotted lines indicate abnormalities in the venation of the right side of the type; the normal venation, as shown on the left side of the type, has been restored in the figure.

Wings hyaline, the veins dark, except C, Sc+R, M+Cu, and 1A in the forewing, which are pale. All the veins of the distal half of the forewing slightly clouded with brown on the adjacent membrane, this clouding becoming wider distally. Pterostigma very hairy, dark brown along costa and around end of Sc; R_1, forming the posterior border of the stigma, is very thick, dark brown and pale yellow alternately in four portions, the dark parts situated basally and before and up to the stump-vein, the yellow parts between these two and from stump-vein to apex of R_1. Cubital loop and clavus of forewing also cloudy, the latter especially between 1A and the posterior margin. Hindwing without any markings.

Habitat.—Tisbury, near Invercargill, N.Z. A single specimen taken by Mr. A. Philpott, 30th December, 1917.

Type.—Holotype in Cawthron Institute collection, Nelson.

Genus ZELANDOPSOCUS n. g.

Characters as given in the key on p. 180. Closely allied to *Philotarsus* Kolbe, but differing from it in the very hairy antennae, the much greater distal breadth of the forewing, and consequently in the manner of folding the wings when at rest, the forewings being held almost vertically, inclined at a very narrow angle to one another. All the veins of the forewing are hairy except only Cu_2.

Genotype.—*Zelandopsocus formosellus* n. sp.

Habitat.—New Zealand only, so far as is known.

Zelandopsocus formosellus n. sp. (Plate 18, fig. 3; and text-fig. 10.)

Forewing, 3 mm.; expanse of wings, 7 mm.

Head pale yellow, marked with crimson and brown. Epicranium yellow with two crimson patches, and carrying a few stiff black bristles. Eyes dull-brownish. Ocelli close together, rose-brown, the median one smaller than the other two. On either side, between lateral ocellus and eye, there is an irregular patch of crimson. Antennae with the two basal joints pale-yellowish, the rest yellowish-brown, furnished with numerous whorls of long delicate hairs; the divisions between the joints not very clearly indicated. Frons with a patch of crimson on each side, near base of antenna. Clypeus shining brown. Clypeolus yellow, with a median brown blotch. Genae yellow. Labrum shining blackish. Maxillary palpi dull-brownish, the distal joint darker.

Thorax shining black, the parts of the mesonotum separated by pale-yellow sutures; metanotum with anterior and posterior median yellow spots. A patch of crimson at the extreme base of each wing. Legs pale-brownish.

Abdomen shining black, touched with pale yellow apically.

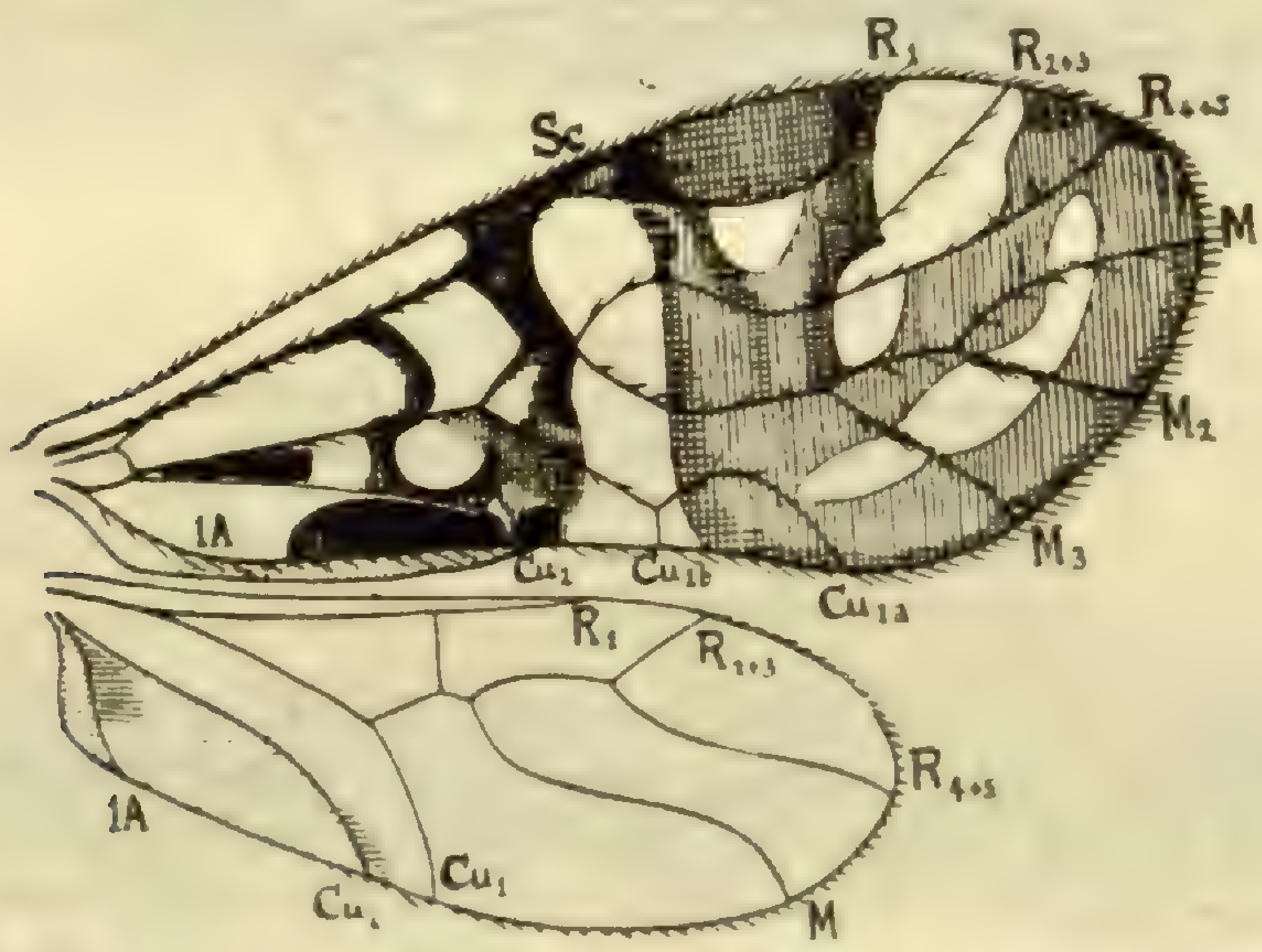


FIG. 10.—*Zelandopsocus formosellus* n. g. et sp. Venation. × 24. (For lettering see fig. 1.)

Wings hyaline, with pale venation. Forewing of normal width basally, but much broader from end of clavus distad; apex broadly rounded; this wing beautifully marked with rich brown and black as shown in text-fig. 10 and in Plate 18, fig. 3. Hindwing hyaline, the clavus suffused with brown.

Habitat.—New Zealand, many localities, but never very common. South Island: Waitati (Mr. W. G. Howes, 12th November, 1916); Tisbury, near Invercargill (Mr. A. Philpott, 4th January, 1918); Dun Mountain, Nelson, several specimens taken by Mr. Philpott and myself, December, 1920, to February, 1921; Tasman, several specimens taken by myself, 24th April, 1921. North Island: York Bay, Wellington Harbour, one specimen taken by myself, 20th March, 1921.

Type.—Holotype (Dun Mountain, 2,000 ft., 3rd February, taken by Mr. Philpott), also a number of paratypes, in Cawthron Institute collection.

This species was first discovered by Mr. W. G. Howes at Waitati in 1916. In order that the type specimens should as far as possible be capable

of being figured in Plate 18, I have selected a better-set specimen from the Dun Mountain as type. In the cases of the two preceding species no well-set specimens exist, and thus it was impossible to photograph them on the plate.

Zelandopsocus formosellus is not only the most beautiful of all the New Zealand Psocoptera, but is indeed one of the most beautiful species known for the whole order throughout the world.

Genus MESOPSOCUS n. g.

Characters as given in the key on p. 180, to which should be added that the cubital loop is very strongly arched, approaching very close to M at the top. In possessing absolutely hairless wings it resembles *Psilopsocus* End., but the latter has a stump-vein attached to the pterostigma as in *Philotarsopsis* n. g.

Genotype.—Mesopsocus unipunctatus Müller.

This genus has not been recorded from the Oriental region, nor does it occur in Australia, so far as is known.

Mesopsocus stigmaticus n. sp. (Plate 18, fig. 4; and text-fig. 11.)

Forewing, 3·5 mm.; expanse of wings, 7·5 mm.

Head: Epicranium, frons, and eyes dark brown, with irregular pale-ochreous markings. Antennae dark brown. Clypeus dark brown, with numerous pale-ochreous striae. Clypeolus pale ochreous. Labrum dark brown. Maxillary palpi brown, distal joint very dark brown.

Thorax dark brown, slightly marked with paler brown. Legs brown.

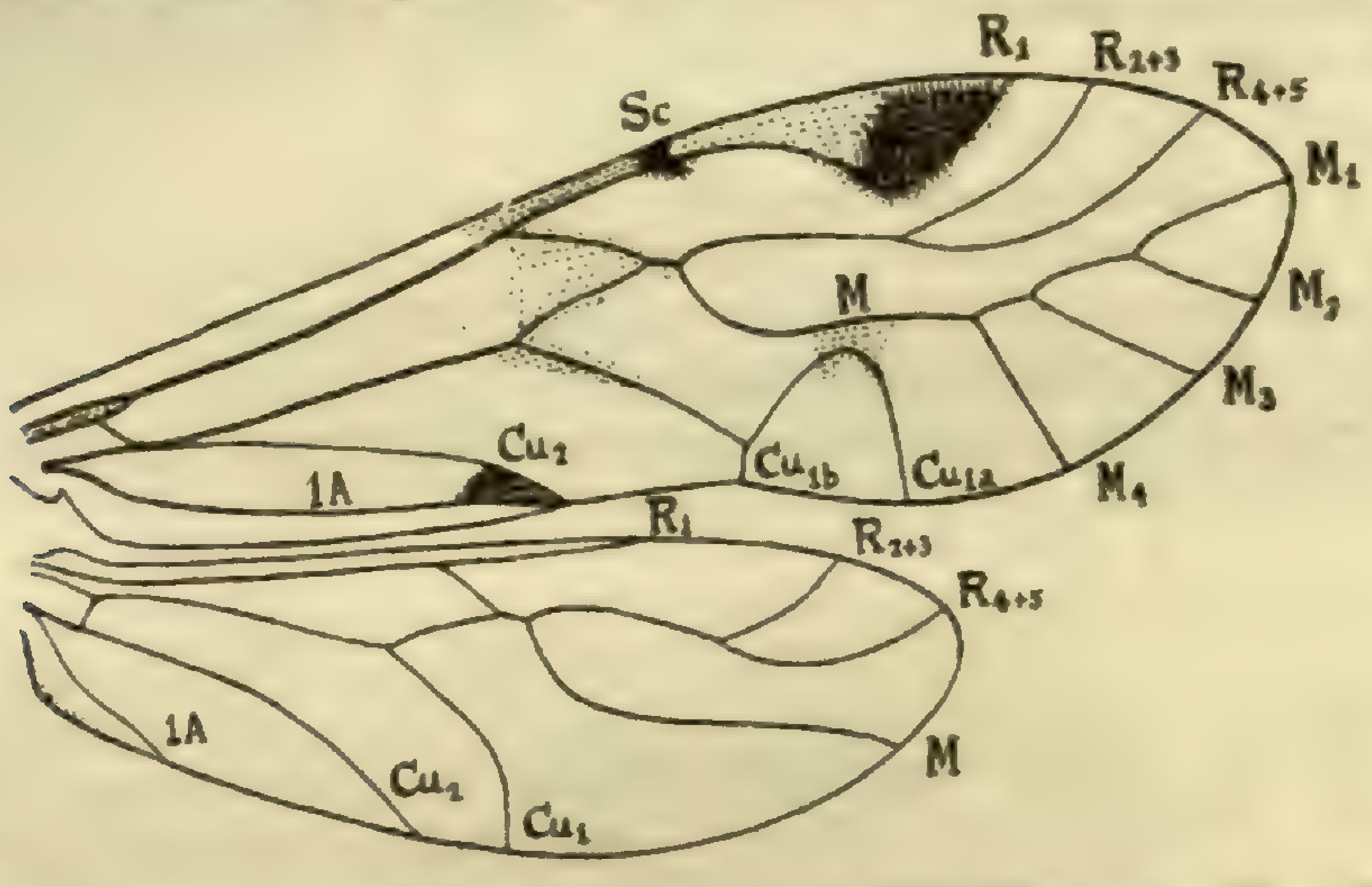


FIG. 11.—*Mesopsocus stigmaticus* n. sp. Venation. × 23. (For lettering see fig. 1.) The right forewing of the type is aberrant, having four branches to M; the left forewing is normal, with three branches.

Abdomen dark brown.

Wings hyaline, with black veins. Forewing with a large irregular black spot filling up the distal convexity of the pterostigma and also reaching somewhat below R_1; the rest of the stigma slightly clouded; at its base a small black spot covering the end of Sc and projecting for a short distance obliquely below R_1; a dark cloud between Cu_2 and 1A at end of clavus; slight clouding around the basal portions of Rs, M, and Cu_1, and also between M and the top of the cubital loop. Hindwing hyaline, without markings.

The right forewing of the type has four well-developed branches to M, while the left forewing is normal, with only three branches.

Habitat.—Dun Mountain, Nelson, 3,000 ft.; taken by Mr. A. Philpott on the 9th February, 1921. A single specimen only.

Type.—Holotype in Cawthron Institute collection.

Family MYOPSOCIDAE.

Antennae with 13 joints. Ocelli present. Maxillary palpi four-jointed, the last joint of normal elongate-oval shape. Tarsi three-jointed, the basal joint longer than the other two together. Venation of the normal type, the forewing with Cu_2 and 1A ending together. Cubital loop of forewing present, either just touching M or fusing with M for a short distance. This family is divided into two subfamilies, as follows:—

Forewing with a cross-vein between pterostigma and Rs .. Subfamily Propsocinae.
Forewing without a cross-vein between pterostigma and Rs Subfamily Myopsocinae.

Only the latter subfamily occurs in New Zealand.

Subfamily Myopsocinae.

Genus Myopsocus Hagen.

In this genus the median vein is much zigzagged in both wings. In the forewing M runs obliquely upwards to meet Rs, then bends sharply downwards, at right angles to its former course, until it reaches the top of the cubital loop, when it again bends obliquely upwards and runs to the apex, dividing into three branches. The basal piece of Rs, the middle piece of M, and the distal piece of Cu_{1a} lie almost in one straight line crossing the wing obliquely. In the hindwing M fuses with Rs for a short distance, then leaves it almost at right angles and curves strongly round to run longitudinally to a point below the apex. The forewings of the species of this genus are more or less heavily marked with brown, grey, or fuscous.

Genotype.—Myopsocus lugens Hagen.

Two species of this genus have been described from Australia, one from New Guinea, and one from New Zealand.

Myopsocus novae-zealandiae Kolbe. (Plate 18, figs. 5, 6; and text-fig. 2.)

Kolbe, H. J., Ueber das Genus *Myopsocus* und dessen Species, *Ent. Nachr.*, ix, 1883, pp. 141–46. (*M. novae-zealandiae* described on p. 145, loc. Wellington.)

Psocus zelandicus Hudson, 1892, *Man. N.Z. Ent.*, p. 107, and pl. xvi, fig. 2, 2*a* (larva). *Myopsocus novae-zealandiae* Kolbe, Hutton, 1899, *Trans. N.Z. Inst.*, vol. 31, p. 211 (mentions that the types of this species were sent by Hutton to McLachlan in 1873).

Forewing—male, 4 – 4·5 mm.; female, 5 – 5·5 mm. Expanse of wings—male, 9 – 10 mm.; female, 11·5 – 12·5 mm.

This species has already been well described by Kolbe and Hutton. It is very much larger than any other known New Zealand Psocopteron, and can be at once recognized by the dark forewings, mottled brown or fuscous, as shown in Plate 18, figs. 5, 6. Points that should be noted are the following: The males are much smaller and darker in colour than the

females. When the forewings are fuscous the pterostigma remains brown, and so shows up very clearly, especially in the males. This brown colour really overlaps the actual pterostigmatic area, as shown in text-fig. 2, where the boundary of the brown colour is shown by the dotted line, lying outside the greatly bent posterior border of the stigma. In the forewing, vein Sc remains separate from R_1, running close above it up to the base of the stigma. In the hindwing, Sc is vestigial. In the forewings of most specimens M just touches Rs at one point and the top of the cubital loop at another; occasionally one may find a specimen in which contact just fails in one or both cases, and sometimes there is fusion for a very short distance. The basal tarsal joint is very long, and carries along its inferior border a complicated comb (text-fig. 2, *b*) formed from about 30 closely set teeth, each tooth being of the form shown in text-fig. 2, *c*. The second tarsal joint is exceedingly short, the third about twice as long as the second.

Habitat.—All parts of New Zealand; frequently very common. Near Hamilton I found many colonies of the larvae, at the end of March, 1921, clustering under the dry bark of large trees of kahikatea (white-pine). They were easily reared by keeping them on pieces of bark in dry tubes closed with cotton-wool. It is very interesting to watch both larvae and imagines feeding on the dry bark by gouging it out with their maxillary chisels, which can be seen at work, projecting far beyond the mouth.

The types of this insect are probably in the McLachlan collection at Lewisham, near London, though I cannot be certain on this point. The New Zealand species is so closely allied to *M. australis* Br., common in many parts of Australia and Tasmania, that it is a matter of great difficulty to separate the two. *M. australis* is generally browner in colour, and in most specimens shows a definite fusion of M with Rs and also with the cubital loop for a short distance, in the forewing. In both species the male carries a pair of hooked terminal appendages, those of *M. australis* appearing to be somewhat shorter and less sharply pointed than in the New Zealand species.

Family CAECILIIDAE.

Antennae rather stoutly built, with 13 joints. Ocelli present, close together. Maxillary palpi four-jointed, the last joint of normal elongate-oval shape. Tarsi with only 2 joints (text-fig. 13, *b*), the basal being the longer, and often more than twice as long as the distal. Venation of normal type, the forewing with Cu_2 and 1A ending together. Cubital loop of forewing either absent, or, if present, then not touching M above it, and not connected with M in any manner.

This family, which is abundantly represented in most parts of the earth, is usually divided into numerous subfamilies, only two of which are to be found in New Zealand. These may be separated as follows:—

Cubital loop of forewing present	Subfamily CAECILIINAE.
Cubital loop of forewing absent	Subfamily PERIPSOCINAE.

Subfamily CAECILIINAE.

To the characters given above should be added the following: Pterostigma not connected with Rs by a cross-vein, but either entirely free or at most with a stump-vein depending from its posterior border. Rs and M in forewing fused together for a short distance, as also in hindwing.

Both the New Zealand genera have a complete fringe of hairs on both wings, and the veins of the forewing are hairy. They may be distinguished as follows:—

Cubital loop moderately to very slightly arched; its top not approaching at all near to M; posterior border of pterostigma normally waved	*Caecilius* Curtis.
Cubital loop very strongly arched, the distance between its top and M above it being much less than the height of the loop; posterior border of pterostigma sharply angulated towards its distal end .. .. (Genotype, *Maoripsocus semifuscatus* n. sp.)	*Maoripsocus* n. g.

Genus Caecilius Curtis.

Characters as given in the above key.

This genus is practically world-wide in distribution, and contains a very large number of described species, including four from New Guinea and three from Australia. Four new species are here described from New Zealand. They may be separated by the following key:—

1	Forewing narrow, less than one-third as broad as long, pterostigma very flat, only one-seventh as broad as long; colour pale creamy, semi-transparent ..	*C. zelandicus* n. sp.
	Forewing broader, a little more than one-third as broad as long; pterostigma with posterior border normally curved; colour pale semi-transparent brown or yellowish	2
2	Veins of forewing with a double set of longish hairs; colour pale semi-transparent brownish	3
	Veins of forewing with only a single set of short hairs; all distal veins and outer margin of clavus infuscate; pterostigma pale yellow	*C. flavistigma* n. sp.
3	Forewing with dark spots at ends of all veins except only Cu_{1b}	*C. apicipunctatus* n. sp.
	No such spots present; size much smaller than above; the forewings uniformly pale semi-transparent brown ..	*C. brunellus* n. sp.

Caecilius zelandicus n. sp. (Plate 18, fig. 7; and text-fig. 12.)

Forewing, 2·9 mm.; expanse of wings, 6·1 mm.

Head entirely pale testaceous, except eyes, which are black; antennae testaceous.

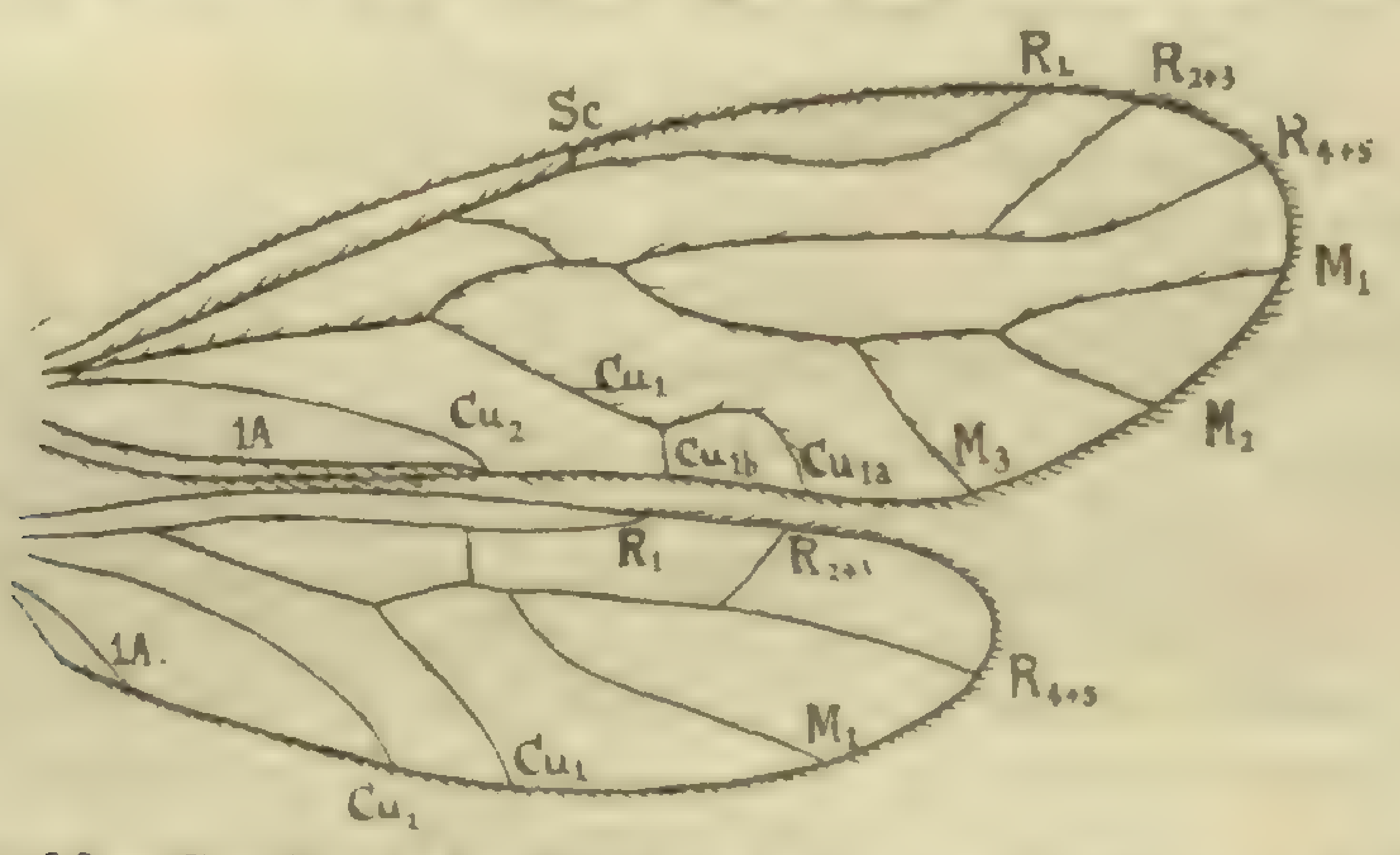


Fig. 12.—*Caecilius zelandicus* n. sp., type. Venation. × 24.
(For lettering see fig. 1.)

Thorax and legs testaceous.

Abdomen testaceous.

Wings: Veins testaceous, those of forewing carrying only a single set of very short hairs. Forewing narrow, less than one-third as broad as long,

semi-transparent cream-colour; pterostigma granulate, very flat, only one-seventh as broad as long. Hindwing hyaline.

Habitat.—Common in native bush in most parts of New Zealand.

Type.—Holotype in Cawthron Institute collection (Nelson, 13th April, 1921, R. J. Tillyard).

Caecilius flavistigma n. sp. (Plate 18, fig. 8; and text-fig. 13.)

Forewing, 3·1 mm.; expanse of wings, 6·5 mm.

Head entirely testaceous, except the eyes and the ocellar tubercle, which are black. Ocelli small, testaceous, placed very close together. Antennae brownish at base, shading to testaceous distally.

Thorax testaceous, the four divisions of the mesothorax dark brown. Legs testaceous.

Abdomen testaceous, marked with lemon-yellow.

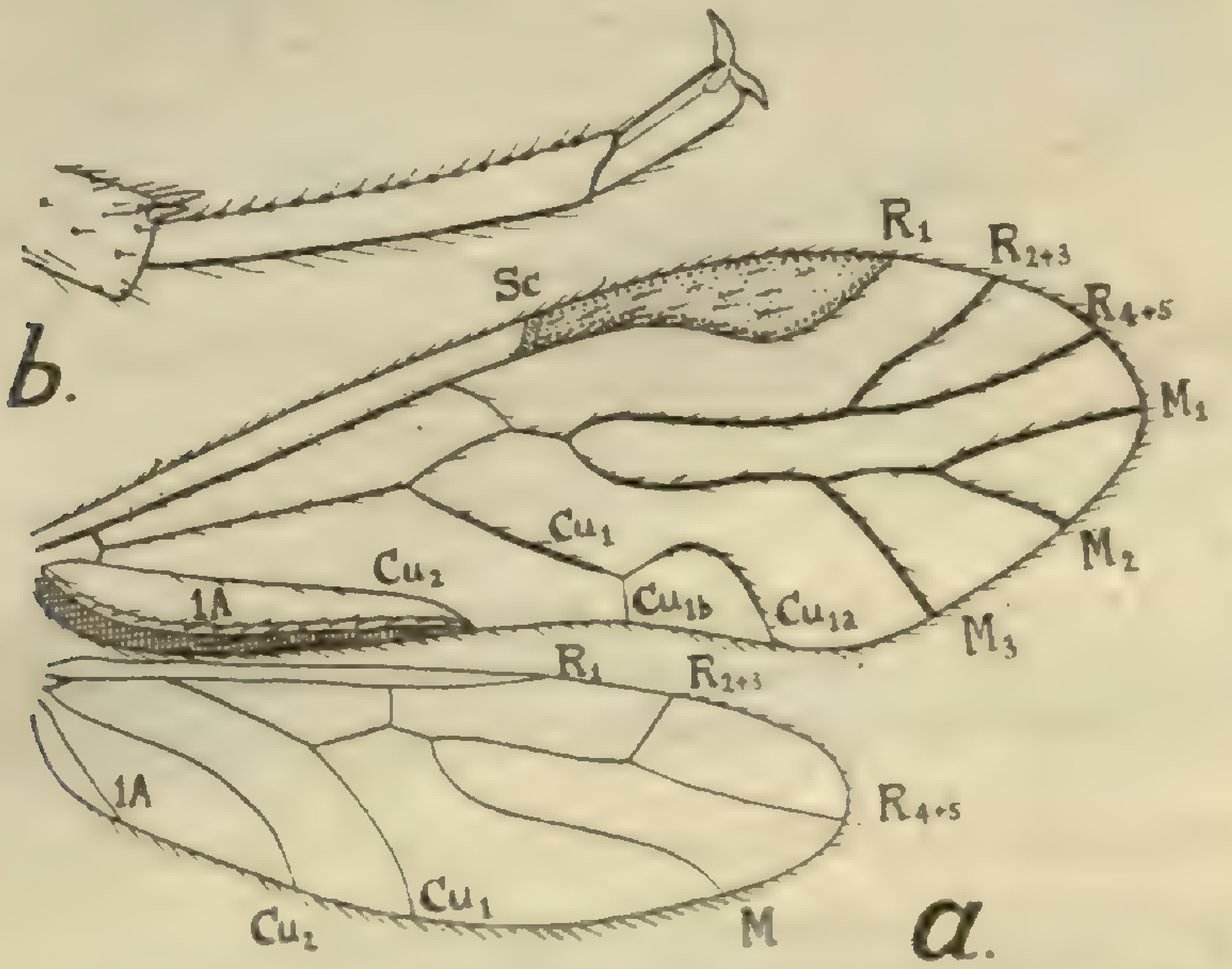


FIG. 13.—*a. Caecilius flavistigma* n. sp., type. Venation. × 24. (For lettering see fig. 1.) *b.* Two-jointed hind tarsus of same. × 45.

Wings: Forewing a little more than one-third as broad as long. Veins pale near base, but becoming darker distally; all the veins of the distal half of the wing strongly infuscated; membrane semi-transparent yellowish-brown; pterostigma of normal shape, about one-fifth as broad as long, pale lemon-yellow in colour; the narrow area between 1A and the posterior border fuscous. Hindwing hyaline.

Habitat.—Nelson, common throughout the summer months, both in native bush and in orchards; Hamilton, one specimen, 28th March, 1921.

Type.—Holotype and series of paratypes in Cawthron Institute collection (Nelson, 13th April, 1921, R. J. Tillyard).

Caecilius apicipunctatus n. sp. (Plate 18, fig. 9; and text-fig. 14.)

Forewing, 3·2 mm.; expanse of wings, 6·6 mm.

Head, thorax, and *abdomen* entirely testaceous. Eyes and ocelli brownish. Antennae with long, slender hairs. Legs testaceous.

Wings: Forewing a little more than one-third as broad as long. Veins testaceous, those of forewing with a double set of long hairs, except Cu_2,

which is hairless. Membrane of forewing suffused with pale semi-transparent brown, and with dark spots present at the apices of all the veins except Cu_{1b}, and also at the origins of Rs and M_3. Pterostigma granulate, hairy

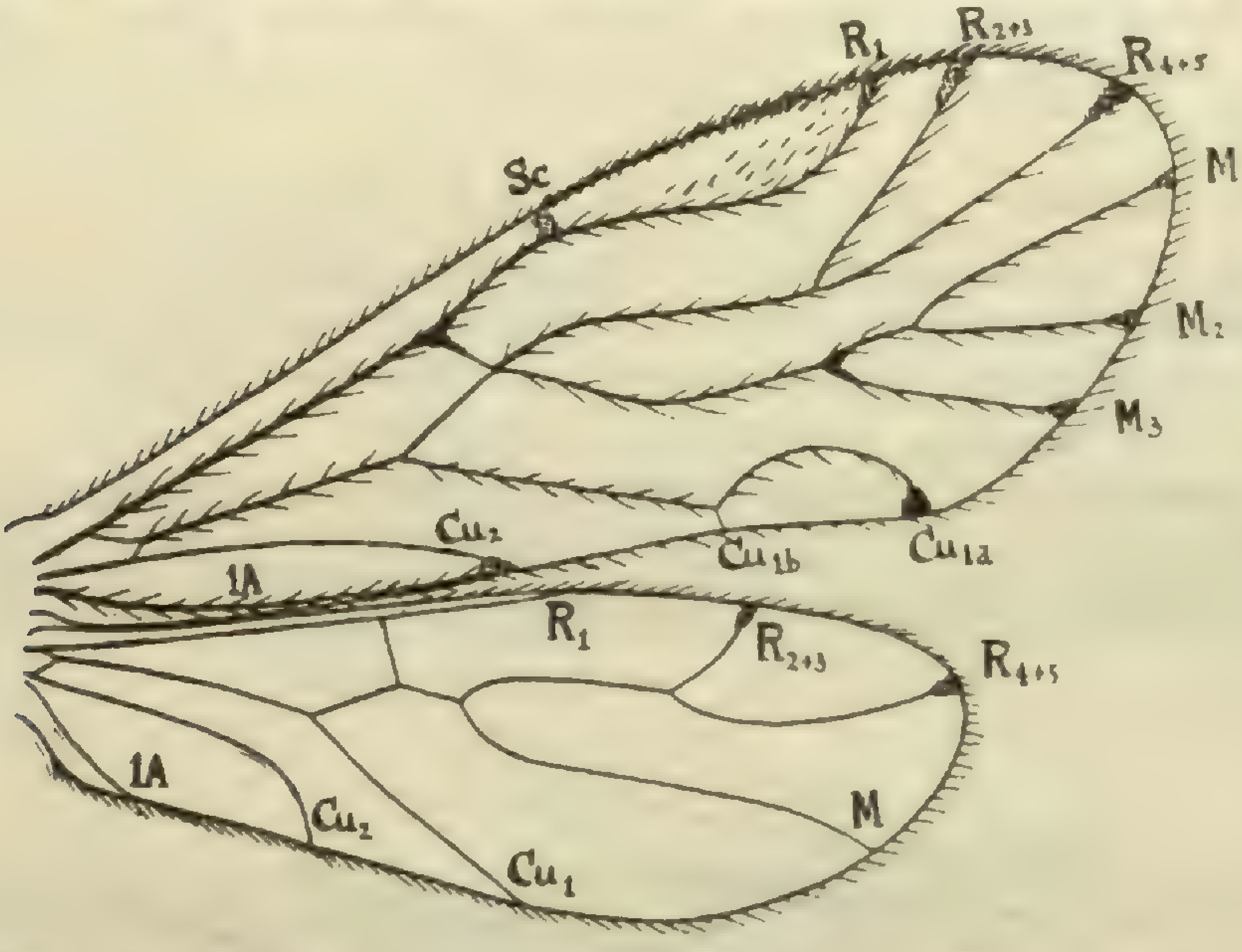


FIG. 14.—*Caecilius apicipunctatus* n. sp., type. Venation. × 27. (For lettering see fig. 1.)

distally. Hindwing hyaline, with dark spots at the apices of the two branches of Rs.

Habitat.—York Bay, Wellington Harbour; taken by Mr. J. G. Myers and myself on the 20th March, 1921; two specimens only.

Type.—Holotype and paratype in Cawthron Institute collection.

Caecilius brunellus n. sp. (Plate 18, fig. 10; and text-fig. 15.)

Forewing, 2·6 mm.; expanse of wings, 5·4 mm.

Head, thorax, and *abdomen* entirely brownish testaceous. Ocelli darker brown. Eyes black and very prominent. Antennae very hairy. Legs brownish testaceous.

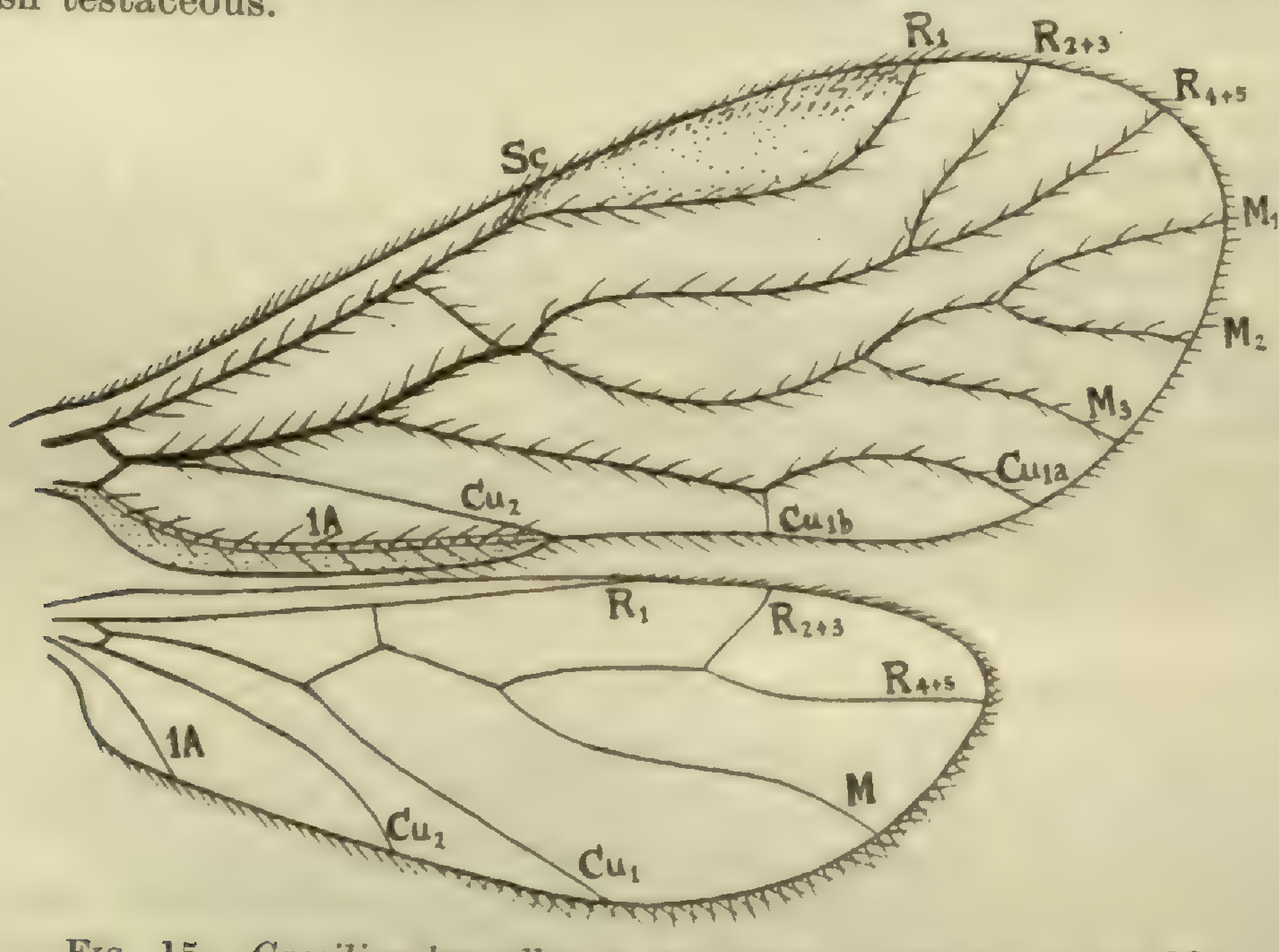


FIG. 15.—*Caecilius brunellus* n. sp., type. Venation. × 38. (For lettering see fig. 1.)

Wings: Forewing about two-fifths as broad as long; all the veins except Cu_2 with a double set of very long hairs; veins testaceous; membrane suffused with pale semi-transparent brown; pterostigma weakly granulate, very long (nearly one-third of entire wing-length), with numerous minute hairs along costal margin; no spots on wing. Hindwihg hyaline.

Habitat.—Hamilton, N.Z. A number of specimens taken by myself while sweeping *Pittosporum* and kahikatea (white-pine), 28th March, 1921.

Type.—Holotype and series of paratypes in Cawthron Institute collection.

Genus MAORIPSOCUS n. g.

Characters as given in the key on p. 188.

Genotype.—*Maoripsocus semifuscatus* n. sp.

Habitat.—New Zealand only, so far as is known.

This genus is closely related to *Kolbea* Bertkau from Ceylon and Singapore, but differs from it in the strongly angulated shape of the pterostigma and in having the wings much less hairy. *Kolbea* also has a partial series of hairs developed distally on the veins of the hindwing.

Maoripsocus semifuscatus n. sp. (Plate 18, fig. 11; and text-fig. 16.)

Forewing, 2·8 mm.; expanse of wings, 6 mm.

Head: Epicranium dark brown; two pale-yellowish patches interior to eyes and a pale ill-defined band behind ocelli isolate a large circular blotch of the ground-colour in the middle. Antennae and eyes dark brown. Ocelli small, placed close together on a prominent black tubercle. Frons and clypeus dark brown. Labrum black, with pale upper margin. *Maxillary palpi* pale-brownish.

Thorax blackish, with very short pale-brown hairs. Legs brown.

Abdomen very dark brown.

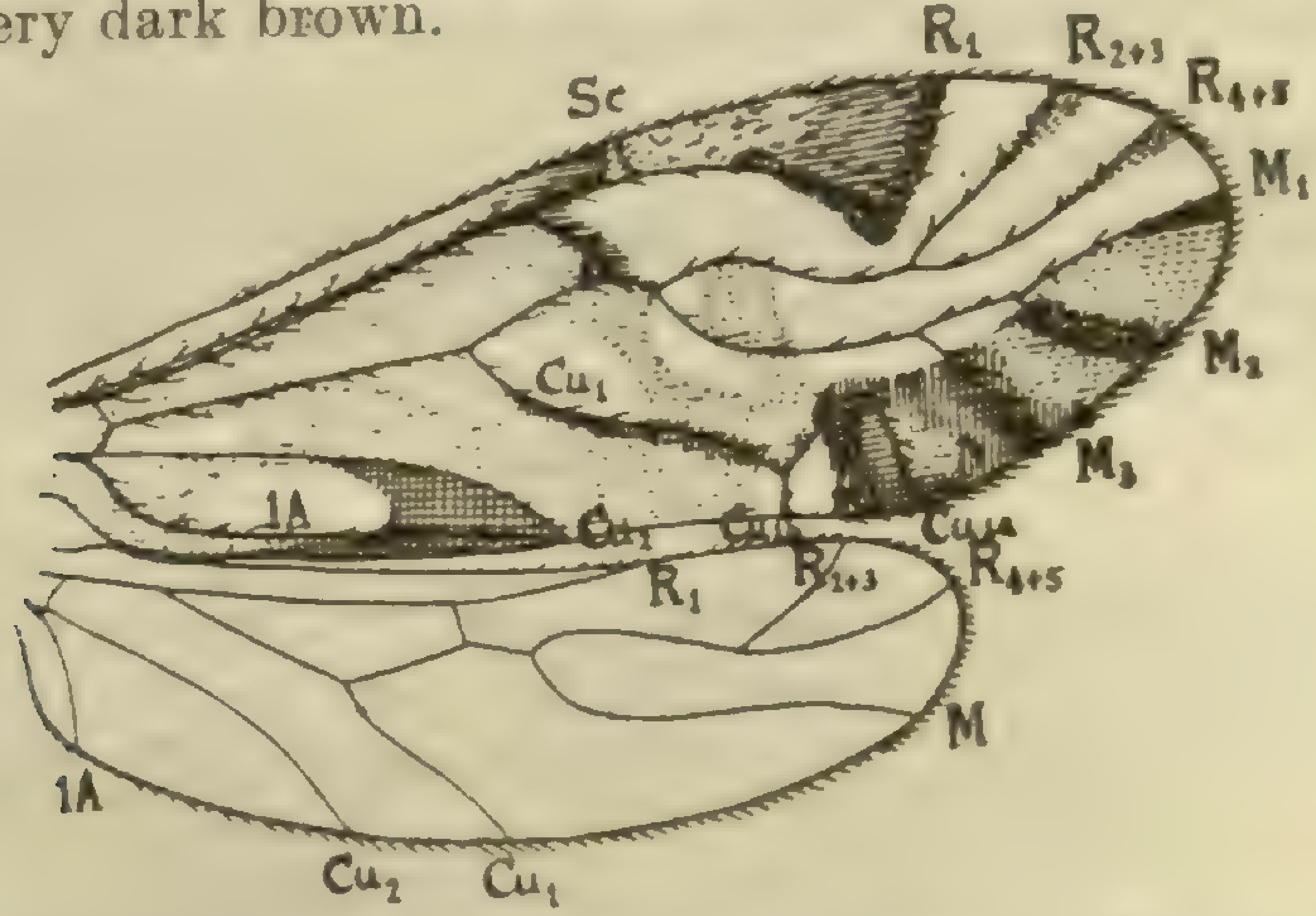


FIG. 16.—*Maoripsocus semifuscatus* n. g. et sp., type. Venation. × 24. (For lettering see fig. 1.)

Wings: Forewings irregularly blotched with various shades of fuscous, as shown in Plate 18, fig. 11, and text-fig. 16. Pterostigma very hairy, a nearly black blotch placed basad from the basal side (Sc), which itself carries a pale-brownish spot; distal half of stigma covered with a very dark blotch which reaches down beyond the prominent angle of the posterior margin towards Rs. Other dark blotches are situated at end of clavus, in the angle between Rs and M where they meet, on the cubital loop,

and the distal ends of the branches of M. The rest of the wing is partially shaded and partially hyaline, as indicated in the figures. Hindwing hyaline, without markings.

Habitat.—Hamilton ; three specimens taken by myself while sweeping kahikatea (white-pine) on the 28th March, 1921. Nelson ; one specimen taken by Mr. Philpott on the 2nd February, 1921.

Type.—Holotype and two paratypes (Hamilton) in Cawthron Institute collection.

Subfamily PERIPSOCINAE.

To the characters given on p. 187 should be added the following : Pterostigma not connected with R by a cross-vein. Rs and M in forewing either meeting at a point or fusing for a short distance.

The genera of this subfamily found in New Zealand may be at once recognized by the complete absence of the cubital loop in the forewing. Only two such genera are at present known, and these may be separated by means of the following key :—

Rs and M fused for a short distance in both wings ; pterostigma of normal shape, with the posterior margin waved *Peripsocopsis* n. g.
(Genotype, *Peripsocopsis maoricus* n. sp.)

Rs and M meeting at one point only in forewing, and connected by a cross-vein in hindwing ; pterostigma subrectangular, with the posterior margin straight .. .. .. *Ectopsocus* McLachlan.

Genus ECTOPSOCUS McLachlan.

Characters as given in the above key, with the addition that the wings are without a fringe of hairs, the veins of the forewing either quite hairless or with only a few very minute hairs along some of them, and the wing-membrane is minutely punctate all over.

Genotype.—*Ectopsocus briggsi* McLachlan.

Habitat.—India, Australia, and New Zealand.

Ectopsocus congener n. sp.

Forewing, 2·3 mm. ; expanse of wings, 5 mm.

Head : Epicranium testaceous, with two squarish dark-brown patches close up to median suture, and irregular mottling with dark brown around the eyes and forwards to bases of antennae. Eyes dark brown. Ocelli

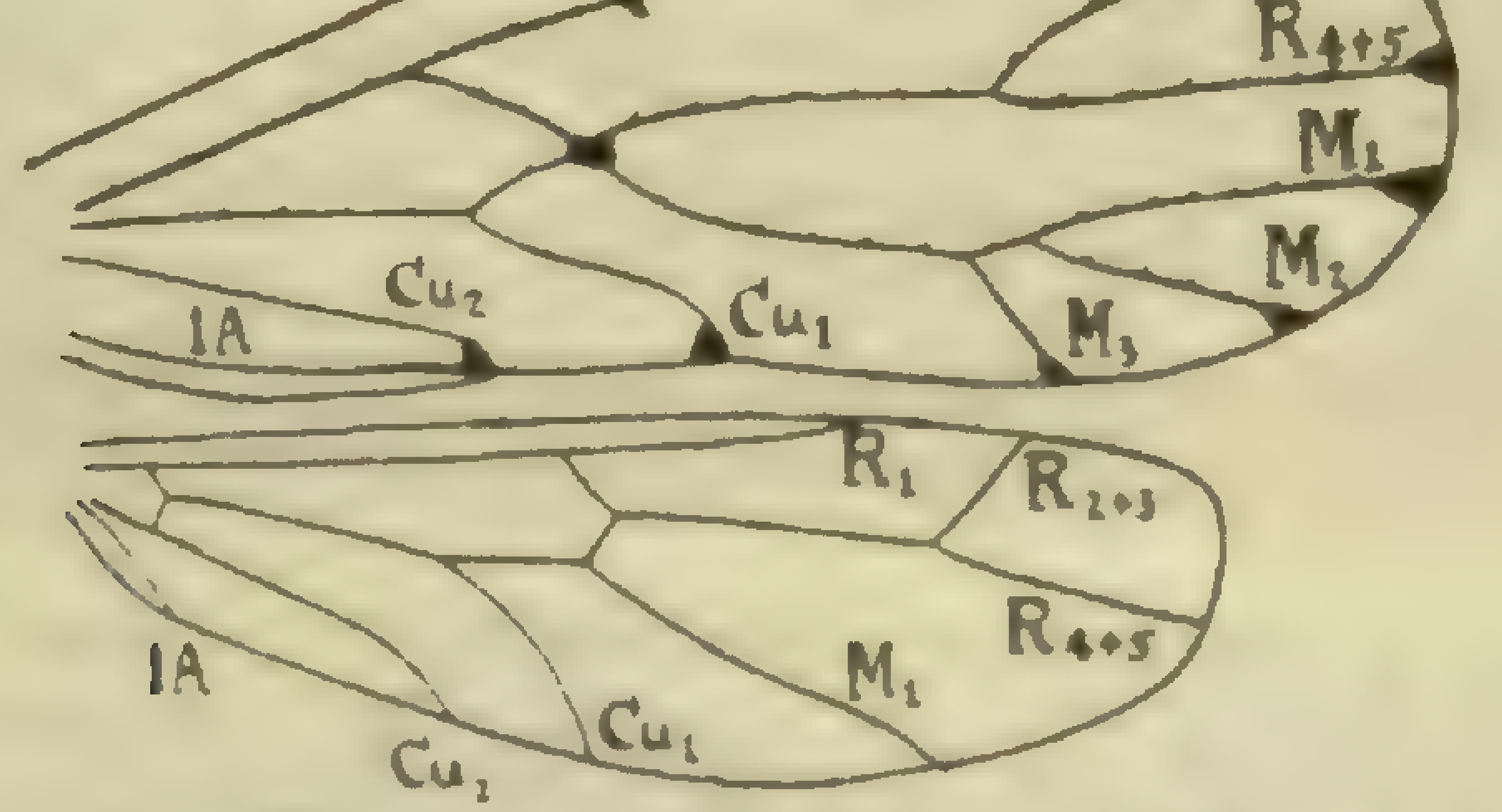


FIG. 17.—*Ectopsocus congener* n. sp., type. Venation. × 18.
(For lettering see fig. 1.)

large, ruby-coloured, bordered with dark brown. Antennae dark brown, stout, with numerous short hairs. Frons fulvous, with pale hairs. Clypeus rich brown, with short pale hairs. Labrum very dark brown. Maxillary palpi brown.

Thorax dark brown, the notal sutures pale testaceous. Legs testaceous.

Abdomen dark brown, marked with pale testaceous.

Wings held at a rather broad angle over the back in repose, so as to approach the horizontal position much more than is usual in this order; apex of forewing bluntly rounded. No fringe of hairs, and only a few very minute hairs on some of the veins of the forewing. Pterostigma elongate, subrectangular. Membrane of both wings minutely punctate, hyaline, the veins dark brown, except only the basal pieces of Rs and M, which are pale testaceous. In the forewing there is a dark blotch at either end of the stigma, and smaller blotches at the apices of all the veins and also at the point where Rs and M meet. Clavus of forewing short, about as long as the stigma. Cu_1 ending up at about half-way along the posterior border of the wing. Stalk of Rs about as long as R_{4+5}, the dichotomy of Rs occurring exactly below the end of the stigma. M_2 arising very little distad from M_3.

Habitat.—Abundant in many localities throughout New Zealand, both in the bush and amongst orchard-trees. Exceedingly abundant around Nelson.

Type.—Holotype (Nelson, 13th April, 1921, R. J. Tillyard) and series of paratypes in Cawthron Institute collection.

This interesting little insect closely resembles the Australian *E. briggsi* McL. in coloration and wing-markings, but differs from it in many important characters, chiefly as follows: In *E. briggsi* McL. the veins of the forewing are quite hairless, Cu_1 ends up well beyond half-way, and the stalk of Rs is much longer than R_{4+5}.

Micropsocus End. was separated from *Ectopsocus* McL. on account of its hairy wings and some slight differences in the venation. Thus it will be seen that, in possessing a few very small hairs on the veins, our new species serves in some measure to reunite these two genera. It has been placed in *Ectopsocus* because its venational scheme agrees with that of this genus.

Genus PERIPSOCOPSIS n. g.

Characters as given in the key on p. 192, with the addition that the wings are entirely hairless and the membrane of both wings minutely punctate all over.

Genotype.—Peripsocopsis maoricus n. sp.

This genus is related to *Peripsocus* Hagen, agreeing with it closely in its venational scheme, but differing from it in so far as *Peripsocus* has a fringe of hairs on both wings and the veins of the forewing are hairy.

Habitat.—New Zealand only, so far as is known.

Three species are here described, which may be separated from one another by the following key:—

1	Forewing with the stalk of Rs as long as R_{4+5}; hindwing very narrow	*P. milleri* n. sp.
	Forewing with the stalk of Rs much shorter than R_{4+5}: hindwing normally shaped	2
2	Forewings with a dark cloud at about one-third from the base of the forewing; distal end of pterostigma with a dark blotch	*P. maoricus* n. sp.
	Forewings with no defined markings, but with only slight even clouding of the membrane, and slightly darker clouding of pterostigma	*P. morulops* n. sp

Peripsocopsis maoricus n. sp. (Plate 18, fig. 12; and text-fig. 18.)

Forewing, 2·9 mm.; expanse of wings, 6·2 mm.

Head: Epicranium very dark brown, with two large yellowish patches posteriorly and running forward from each of these an irregular pale-yellowish area, isolating the three pinkish ocelli on a small rounded black patch, and reaching outwards past the bases of the antennae to a point in front of the eyes. Antennae brown, rather stout, short, less than half as long as forewing. Eyes black. Frons a small brown area in front of ocelli. Clypeus testaceous, with brown striae. Labrum blackish. Maxillary palpi brown.

Thorax black, the notal sutures brown. Legs brownish.

Abdomen blackish, with some yellow markings.

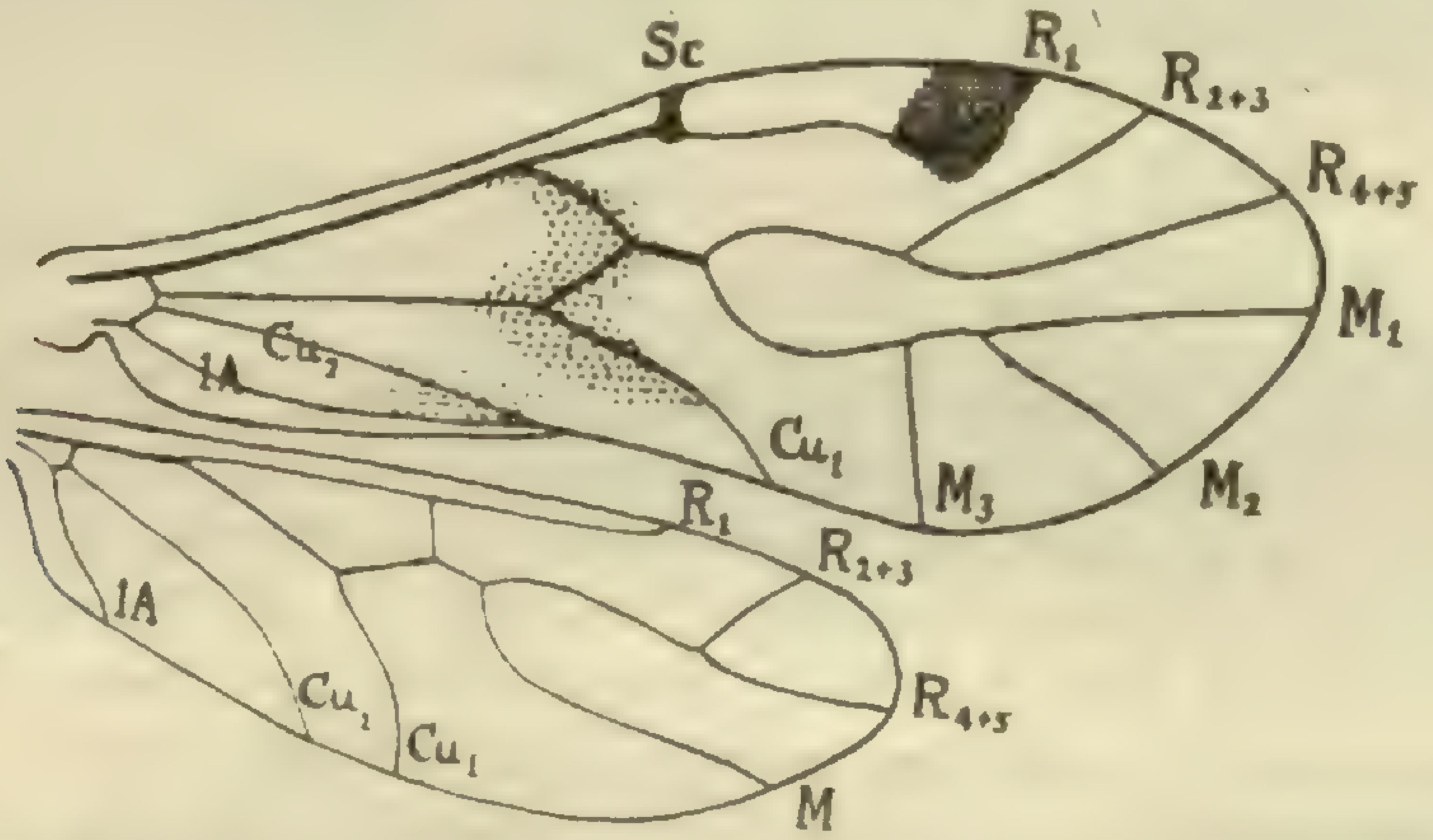


FIG. 18.—*Peripsocopsis maoricus* n. g. et sp. Venation. × 24. (For lettering see fig. 1.)

Wings: Forewings hyaline, with a black spot at base of stigma, covering Sc, a larger blackish blotch covering distal end of stigma and extending somewhat below it towards R_{2+3}, and a large cloud, darkest towards the middle, situated at about the basal third of the wing, as shown in text-fig. 18, and covering the basal piece of Rs, the fused piece of Rs and M, the basal piece of M, and the basal half of Cu_1, all these veins being black and thickened. Stalk of Rs in forewing much shorter than R_{4+5}. Hindwing hyaline.

Habitat.—York Bay, Wellington Harbour: three specimens taken by Mr. J. G. Myers and myself on the 20th March, 1921. Nelson; one specimen taken by Mr. Philpott on the 12th May, 1921.

Type.—Holotype and two paratypes (York Bay) in Cawthron Institute collection.

Peripsocopsis morulops n. sp. (Plate 18, fig. 13; and text-fig. 19.)

Forewing, 2·8 mm.; expanse of wings, 6 mm.

Head: Epicranium pale ochreous margined with dark brown, and with a median bilobed patch of same colour projecting forward from occiput towards ocelli. Eyes very large, black, the individual facets very convex, giving the eye the appearance of a blackberry (*morulops* = mulberry-eyed). Ocelli pink, on a circular black patch. Antennae dark brown, very hairy, more than half as long as forewing. Frons, clypeus, and labrum brownish; no striae on clypeus.

Thorax blackish, the mesothoracic antedorsum divided longitudinally by a pale line and marked posteriorly and laterally with testaceous. Legs brown.

Abdomen blackish.

Wings : Veins brown, membrane slightly clouded. No markings except a dark spot at base of pterostigma, covering Sc. Pterostigma granulate, slightly clouded, especially along Sc. Stalk of Rs in forewing much shorter than R_{4+5}. Hindwing subhyaline.

Habitat.—Hamilton, not uncommon ; taken by myself while sweeping kahikatea (white-pine), 28th March, 1921.

Type.—Holotype and series of paratypes in Cawthron Institute collection.

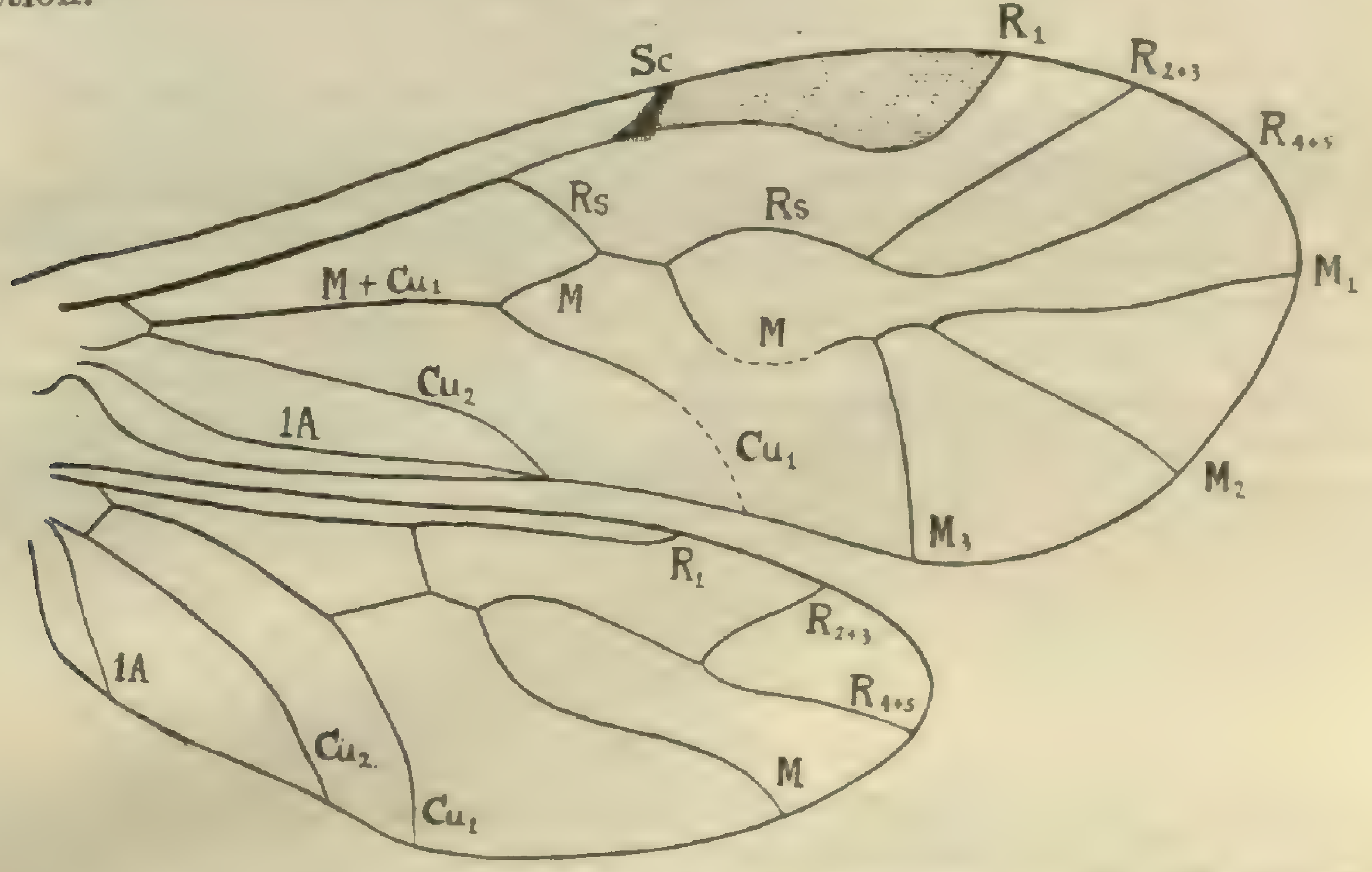


FIG. 19.—*Peripsocopsis morulops* n. g. et sp. Venation. × 40. (For lettering see fig. 1.)

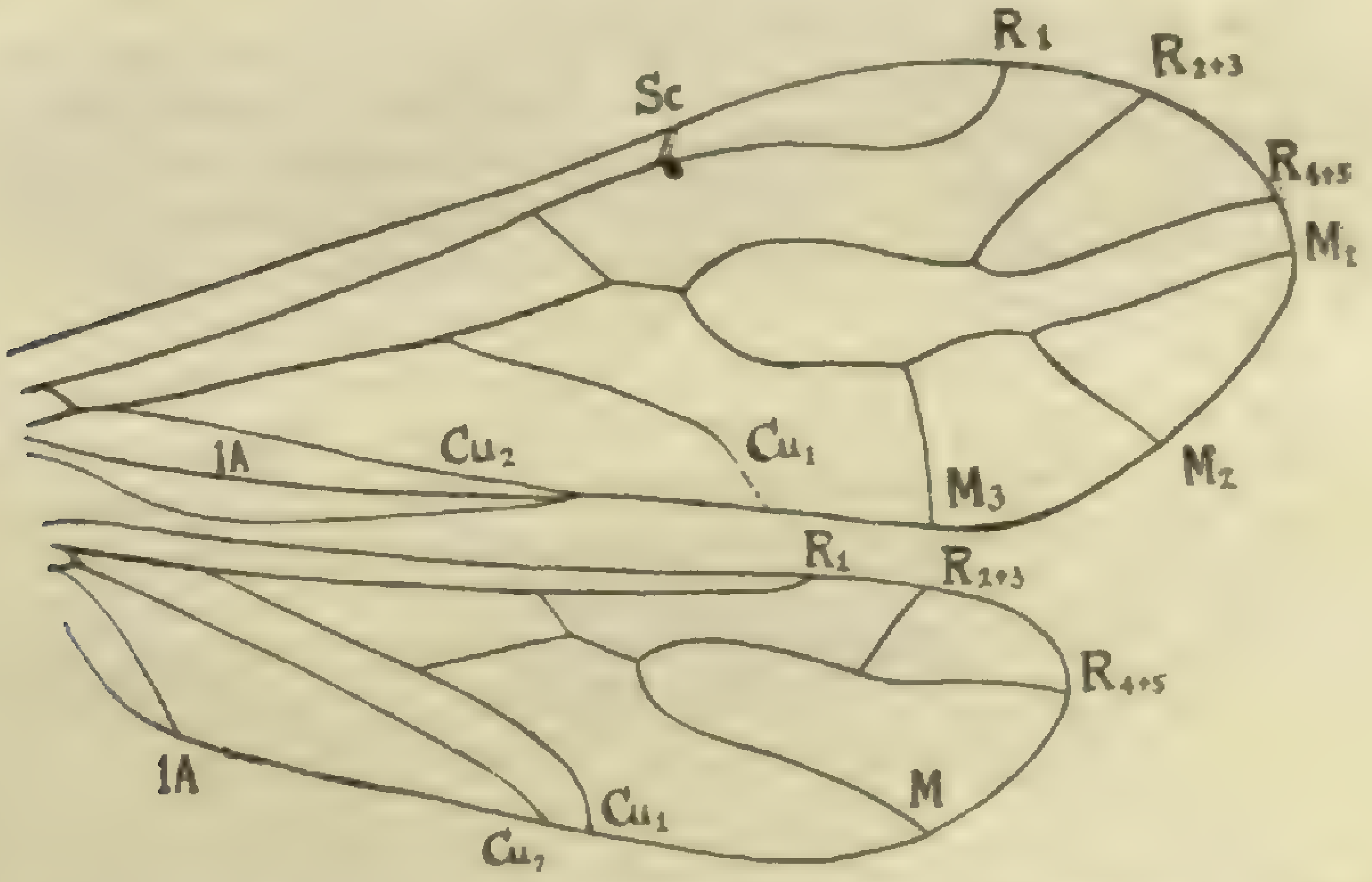


FIG. 20.—*Peripsocopsis milleri* n. g. et sp. Venation. × 32. (For lettering see fig. 1.)

Peripsocopsis milleri n. sp. (Plate 18, fig. 14 ; and text-fig. 20.)

Forewing, 2·4 mm. ; expanse of wings, 5 mm.

Head : Epicranium blackish, with two patches of pale brown interior to eyes and extending forward to bases of antennae. Eyes black. Ocelli pink, on a blackish tubercle. Antennae very dark brown, moderately

hairy, more than half as long as forewing. Frons, clypeus, and labrum dark shining brown; no striae on clypeus. Maxillary palpi blackish.

Thorax black. Legs very dark brown.

Abdomen black marked with brown and yellow.

Wings: Forewing irregularly suffused with fuscous, leaving paler areas along $M + Cu_1$, Cu_2, transversely across from base of stigma to beyond end of Cu_1 and below the dichotomy of Rs; darker clouding along costal space up to stigma, widely around the basal piece of Rs, between Cu_1 and Cu_2, in the loop between Rs and M beyond their fusion, and around M_2 and M_3. A small black stump projects downwards from basal posterior angle of stigma. Stalk of Rs in forewing as long as R_{4+5}. Hindwing very narrow, slightly clouded all over.

Habitat.—Hamilton; a single specimen taken by myself while sweeping on the 28th March, 1921. Since describing this specimen I have received a large number of examples of this species from Wellington; these were found on *Gloeocapsa* by Mr. D. Miller, Government Entomologist. These are somewhat larger on the average than the type specimen from Hamilton.

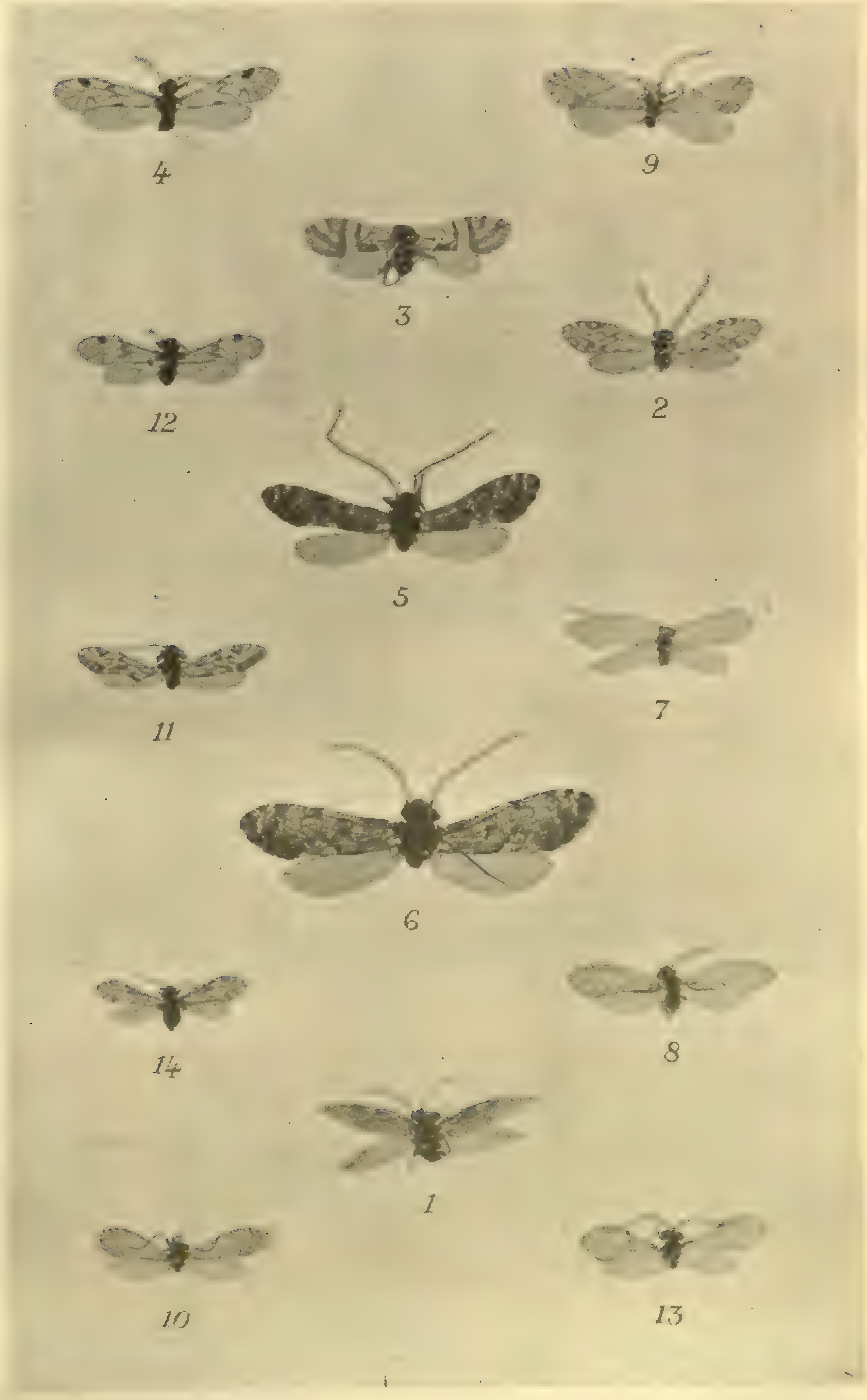
Type.—Holotype (Hamilton) in Cawthron Institute collection. This species is dedicated to my friend Mr. David Miller, Government Entomologist.

PLATE 18.

(All figures are four times natural size.)

FIG. 1.—*Oxypsocus hamiltoni* n. g. et sp.; type specimen.
FIG. 2.—*Philotarsus maculatus* n. sp.; type specimen.
FIG. 3.—*Zelandopsocus formosellus* n. g. et sp.; type specimen.
FIG. 4.—*Mesopsocus stigmaticus* n. g. et sp.; type specimen.
FIG. 5.—*Myopsocus novae-zealandiae* Kolbe; male from Hamilton.
FIG. 6.—*Myopsocus novae-zealandiae* Kolbe; female from Hamilton.
FIG. 7.—*Caecilius zelandicus* n. sp.; type specimen.
FIG. 8.—*Caecilius flavistigma* n. sp.; type specimen.
FIG. 9.—*Caecilius apicipunctatus* n. sp.; type specimen.
FIG. 10.—*Caecilius brunellus* n. sp.; type specimen.
FIG. 11.—*Maoripsocus semifuscatus* n. g. et sp.; type specimen.
FIG. 12.—*Peripsocopsis maoricus* n. g. et sp.; type specimen.
FIG. 13.—*Peripsocopsis morulops* n. g. et sp.; type specimen.
FIG. 14.—*Peripsocopsis milleri* n. g. et sp.; type specimen.

(Plate taken from a direct photographic enlargement by Mr. W. C. Davies, Curator of the Cawthron Institute.)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ART. 18.—*The Stone-flies of New Zealand (Order Perlaria), with Descriptions of New Genera and Species.*

By R. J. TILLYARD, M.A., Sc.D. (Cantab.), D.Sc. (Sydney), C.M.Z.S., F.L.S., F.E.S.; Entomologist and Chief of the Biological Department, Cawthron Institute, Nelson, N.Z.

[*Read before the Nelson Institute, 19th October, 1921; received by Editor, 26th October, 1921; issued separately, 17th February, 1923.*]

THE stone-flies, or Perlaria, form a very distinct order of insects, characterized by a combination of a primitive orthopteroid form of imago with an aquatic hemimetabolous form of larva. The perfect insects may at once be recognized by the following principal characters: *Head* wider than long, with rather small compound eyes placed wide apart: antennae long and many-segmented; mouth-parts mandibulate; no constricted neck region. *Thorax* with very distinct prothorax, the pronotum large and more or less flattened; meso- and meta-thorax quite separate and well developed, so that the wings are fairly wide apart at their bases; legs with short coxae, usually placed wide apart, the femora rather flattened, the tarsi three-segmented. *Abdomen* with ten distinct segments and a pair of anal cerci, which may consist of from one to very many segments; no appendix dorsalis. *Wings* in the position of rest folded longitudinally down the body, either more or less flatly or wrapped around it; the hindwing with a broad anal fan, which is folded under the rest of the wing when at rest. Ordinal characters in the wing-venation are the condition of M (which always has only two branches), the presence of a series of intercubital cross-veins in the forewing, and the position of Cu_2 just anterior to the cubito-anal furrow; in the hindwing there is always some amount of fusion between Rs and M close to the base of the wing, and 1A runs parallel and very close to Cu_2.

The perfect insects fly but little, and are usually to be found in close proximity to the streams in which their larvae live, either resting on rocks or hiding amongst the foliage fringing the water's edge, from which they can best be dislodged by sweeping.

The larvae are in general of a similar shape to the imagines, and are usually to be found in those parts of the stream where the water runs fastest, in cascades and rapids. Some are active, some very sluggish; but all alike possess great power of clinging to rocks against the rush of the water. In many cases external gills are developed on different parts of the body: the form and position of these gills afford valuable family characters within the order. The larvae are of economic value as trout-food.

Very little is known about the stone-flies of New Zealand, as the order has been greatly neglected both by collectors and by systematic entomologists. Only seven species have so far been described, though a season's careful collecting by Mr. W. G. Howes, of Dunedin, and myself has produced four times that number. The order is especially well represented in the colder parts of New Zealand, and a large number of the new species come from localities in Otago and Southland. These are being studied by Mr. Howes, and are not dealt with in this paper. The main object in

view in writing the present paper is to give reliable keys to the New Zealand families and genera, and only secondarily to describe some new species taken by myself in the North Island, and by Mr. Howes and myself in the Arthur's Pass district of the South Island. To save the space required for a full historical *résumé*, full references are given under each genus and species to all previously published descriptions and accounts of New Zealand stone-flies.

Before giving keys to the families and genera, or entering upon the descriptions of species, it will be necessary to explain the terminology used for the wing-venation. This is the Comstock-Needham system, the notation of which is given in full in the legend of fig. 1. Besides the veins, there are also the cross-veins and the separate areas of the wing to be considered, neither of which are notated in the figures. For cross-veins the rule is to name them from the main veins which they connect. In the Perlaria the most important sets of cross-veins are the following:—

(1.) The *medio-cubitals*, a series of long cross-veins connecting the main stem of M with Cu_1 below it. The series begins with M_5, which was originally (as shown by many fossil forms) a true branch of M, and ends with the last long cross-vein before or at the forking of M. Whether this series is complete or incomplete is a character of generic and sometimes of family importance.

(2.) The *inter-cubitals*, a series joining Cu_1 with Cu_2 below it. This series is complete for at least the basal portion of Cu_2 in the forewing throughout the order.

(3.) The *cubito-anals*, a series joining Cu_2 with 1A below it. This series is complete in the forewings of Eustheniidae only.

(4.) The *inter-anals*, connecting the anal veins with one another. Their number, form, and position are of great value in classification. On the anal fan they are present in Eustheniidae only.

(5.) The *distal cross-veins*, a general term to comprise all the irregularly placed cross-veins lying in the distal portion of the wing. These are absent in Nemouridae.

(6.) The *transverse cord*, or *anastomosis*, is formed, in the family Nemouridae only (figs. 17, 18), by alignment of the sole remaining inter-radial, radio-median, and medio-cubital cross-veins with short bent portions of the main veins, at about the middle of the wing, so as to form a continuous line crossing the wing obliquely from R to Cu_1.

Besides the above there are two important sets of veinlets—*i.e.*, short branches of main veins resembling cross-veins, but, unlike them, preceded in the larval wing by tracheae. These are—

(1.) The *costal series of veinlets*, a short set of anterior branches of vein Sc, running across the costal space. One of these, situated not far from the base, persists throughout the order in all forms in which the complete set has been lost. This is called the *humeral veinlet* (*hm*).

(2.) The *pterostigmatic veinlets*, lying in the region of the pterostigma—*i.e.*, the space between R_1 and the costal margin, from the end of Sc to the end of R_1. The most persistent of these is formed, as Comstock has shown, by the forking of the end of Sc. The lower branch of the fork bends down and fuses with R_1 for a short distance, finally leaving it again as a free veinlet running upwards to the costa. This veinlet is labelled Sc_2. When a second veinlet is present, more distally placed, it is formed by the forking of R_1 near its end, and is labelled R_{1a}. Only rarely do we meet with more than these two pterostigmatic veinlets in the Perlaria.

For the separate areas of the wing, or *wing-spaces*, the rule is that they should be named from the vein bordering them anteriorly. Thus the costal space lies between C and Sc, the subcostal between Sc and R, and so on. When a space is bordered by a branch of a main vein anteriorly it takes the name and notation of that branch. To avoid confusion the notation for wing-spaces is written without capitals—*e.g.*, Sc means "subcostal vein"; *sc*, "subcostal space." The pterostigma is a specially named area, defined in the preceding paragraph: in the forewing it is sometimes more heavily chitinized than the rest of the membrane.

The *anal area* is the whole area lying posterior to the cubito-anal furrow, and carries on it all the anal veins, which are convex. In the forewing it is often spoken of as the *clavus*. In the hindwing it is greatly enlarged, and is known as the *anal fan*. The contour of the outer margin of the hindwing is strongly broken by a re-entrant angle or bay separating the anal fan from the rest of the wing in all families of Perlaria except the Eustheniidae (fig. 1); in this latter family the outer margin forms a single continuous curve. The number of veins on the anal fan, their condition, whether branched or simple, and the presence or absence of cross-veins between them, are important family characters within the order.

KEY TO THE FAMILIES OF THE ORDER PERLARIA FOUND WITHIN NEW ZEALAND.

A. *Imagines.*

1	Large insects with numerous cross-veins on all parts of the wing, including the anal fan, whose margin forms an unbroken contour with that of the rest of the hindwing ..	EUSTHENIIDAE.
	Medium to small (rarely large) insects in which the anal fan has no cross-veins (rarely one only), and its margin joins the margin of the rest of the hindwing in a re-entrant angle or bay	2
2	Transverse cord absent: distal cross-veins present	3
	Transverse cord present: no distal cross-veins.	NEMOURIDAE.
3	Forewing with Sc_1 ending up beyond two-thirds of the wing-length from the base, leaving a short pterostigmatic region beyond it. Anal fan with seven or eight main veins, inclusive of 1A; first branch of 2A a forked vein	AUSTROPERLIDAE.
	Forewing with Sc_1 ending up at between one-half and two-thirds of the wing-length from the base, thus leaving a long pterostigmatic region beyond it. Anal fan with only six main veins, including 1A, and none of them forked ..	LEPTOPERLIDAE.

B. *Larvae.*

1	Larvae with visible gills	2
	Larvae without visible gills	3
2	Gills a series of paired latero-vental abdominal appendages on segments 1–5 or 1–6	EUSTHENIIDAE.
	Gills a rosette of numerous small filaments arranged around the anus	LEPTOPERLIDAE.
3	Larvae of small size and normal shape, with minute cerci consisting only of a single segment	NEMOURIDAE.
	Larvae of moderate size and of long, cylindrical shape, with short cerci consisting of a moderate number of short segments	AUSTROPERLIDAE.

Family EUSTHENIIDAE.

Subfamily STENOPERLINAE.

Insects of large size, slender build, and of green, yellow, brown, or grey coloration. Forewing about five times as long as broad, the costa not dilated basally. Cerci short. Male with short superior appendages and short upturned copulatory hook.

This subfamily is found in southern Chile, New Zealand, eastern Australia from Queensland to Victoria, and South Australia, but not Tasmania.

Genus Stenoperla. (Fig. 1.)

Moderately large insects, expanding from 50 mm. to 70 mm. Antennae from one-half to two-thirds as long as forewing. Pronotum somewhat heart-shaped, about as wide as long. Costal series of veinlets few and incomplete, there being always a long gap between the humeral veinlet and the next one. Medio-cubital cross-veins in forewing forming only a single row of cellules, only occasionally connected by a cross-bar.

Genotype.—Stenoperla prasina (Newman). New Zealand.

The only other described species of this genus is *S. australis* Till. from eastern Australia, but an undescribed species of a green colour has also been found in Queensland.

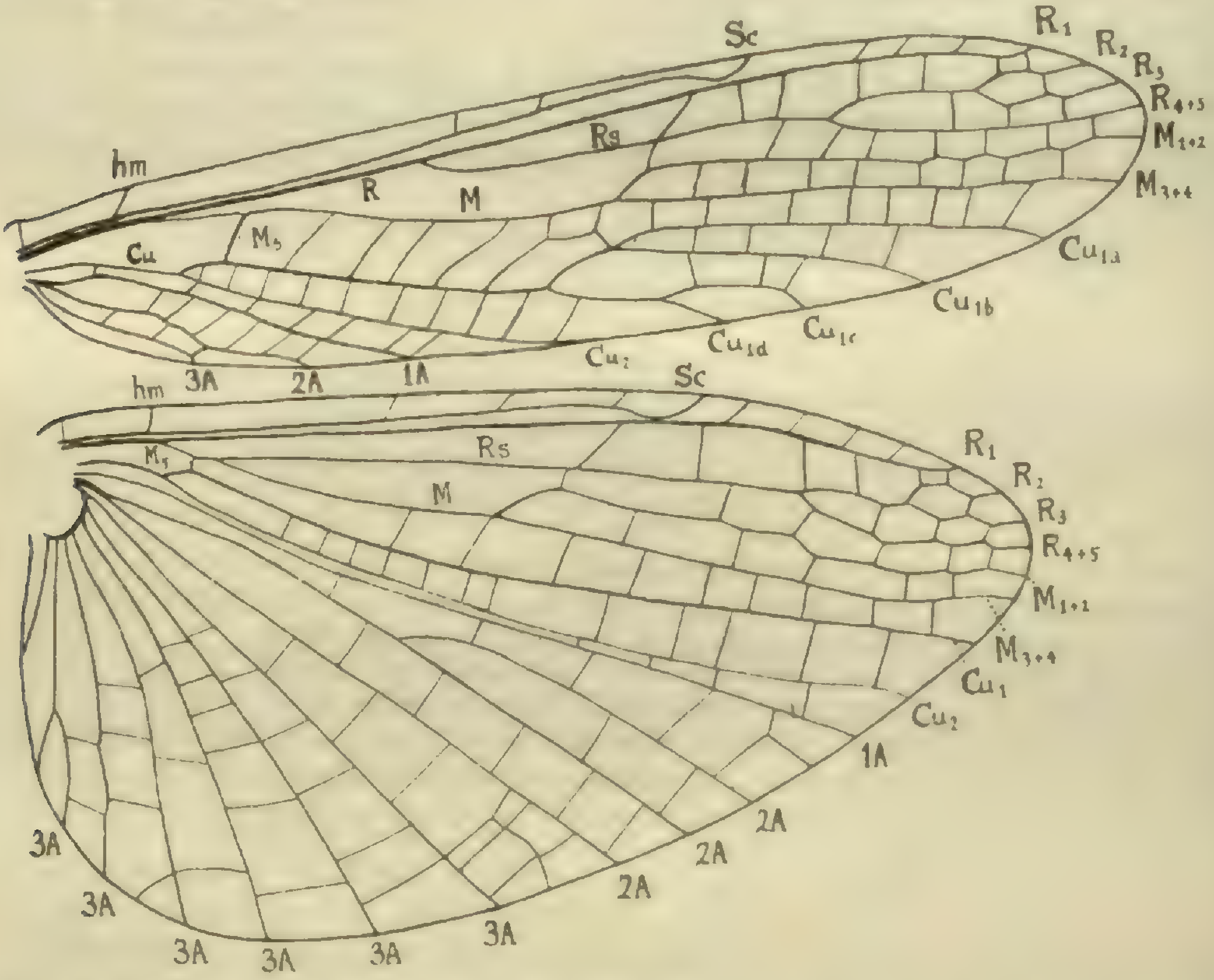


Fig. 1.—Wing-venation of *Stenoperla prasina* (Newm.). 1A, 2A, 3A, the three anal veins; Cu, cubitus; Cu_1, first cubitus, with its branches Cu_{1a} to Cu_{1d}; Cu_2, second cubitus; *hm*, humeral veinlet; M, media; M_{1+2}, M_{3+4}, its two main branches; M_5, its archaic basal posterior branch, which has become the most basal of the medio-cubital series of cross-veins; R, radius; R_1, its main stem; Rs, radial sector, with its branches R_2, R_3, and R_{4+5}; Sc, subcosta.

Stenoperla prasina (Newman). (Fig. 1.)

Chloroperla prasina Newman, 1845, *Zoologist*, vol. 3, p. 852. *Hermes prasinus* Walker, 1852, *Cat. Neur. Brit. Mus.*, p. 206. *Stenoperla prasina* McLachlan, 1866, *Trans. Ent. Soc.*, ser. 3, vol. 5, p. 354; Hudson, 1892, *Manual Entom. N.Z.*, p. 106, pl. 16, fig. 3; Hutton, 1899, *Trans. N.Z. Inst.*, vol. 31, p. 212; Hudson, 1904, *N.Z. Neuroptera*, p. 5, pl. 1, figs. 4–5; Tillyard, 1921, *Proc. Linn. Soc. N.S.W.*, vol. 46, pt. 2, p. 233, pl. 15, fig. 9 and text-figs. 1, 4.

This species, easily recognized by its large size and by the bright-green coloration of the wings, is found in all parts of New Zealand where there is running water. Occasionally a yellow variety is found, in which the wings are somewhat shorter than in typical specimens.

Type in British Museum collection.

Family AUSTROPERLIDAE.

Tillyard, *Canadian Entomologist*, Feb., 1921, p. 40.

This family is confined to New Zealand, Tasmania, and Victoria. There are only two genera, *Austroperla* Needham and *Tasmanoperla* Tillyard. Both genera have the second inter-anal cross-vein (fig. 2, *k*) strongly thickened.

Genus AUSTROPERLA Needham. (Fig. 2.)

Needham, 1905, *Proc. Ent. Soc. Washington*, vol. 18, p. 109. *Heteroperla* Hare, 1910, *Trans. N.Z. Inst.*, vol. 42, p. 30.

Genotype.—Austroperla cyrene (Newman).

This genus is distinguished from *Tasmanoperla* Till. by having, in the forewing, a definite anal angle, distad from which the posterior margin runs almost parallel with the costal margin of the wing, and also by the much weaker formation of the distal cross-veins.

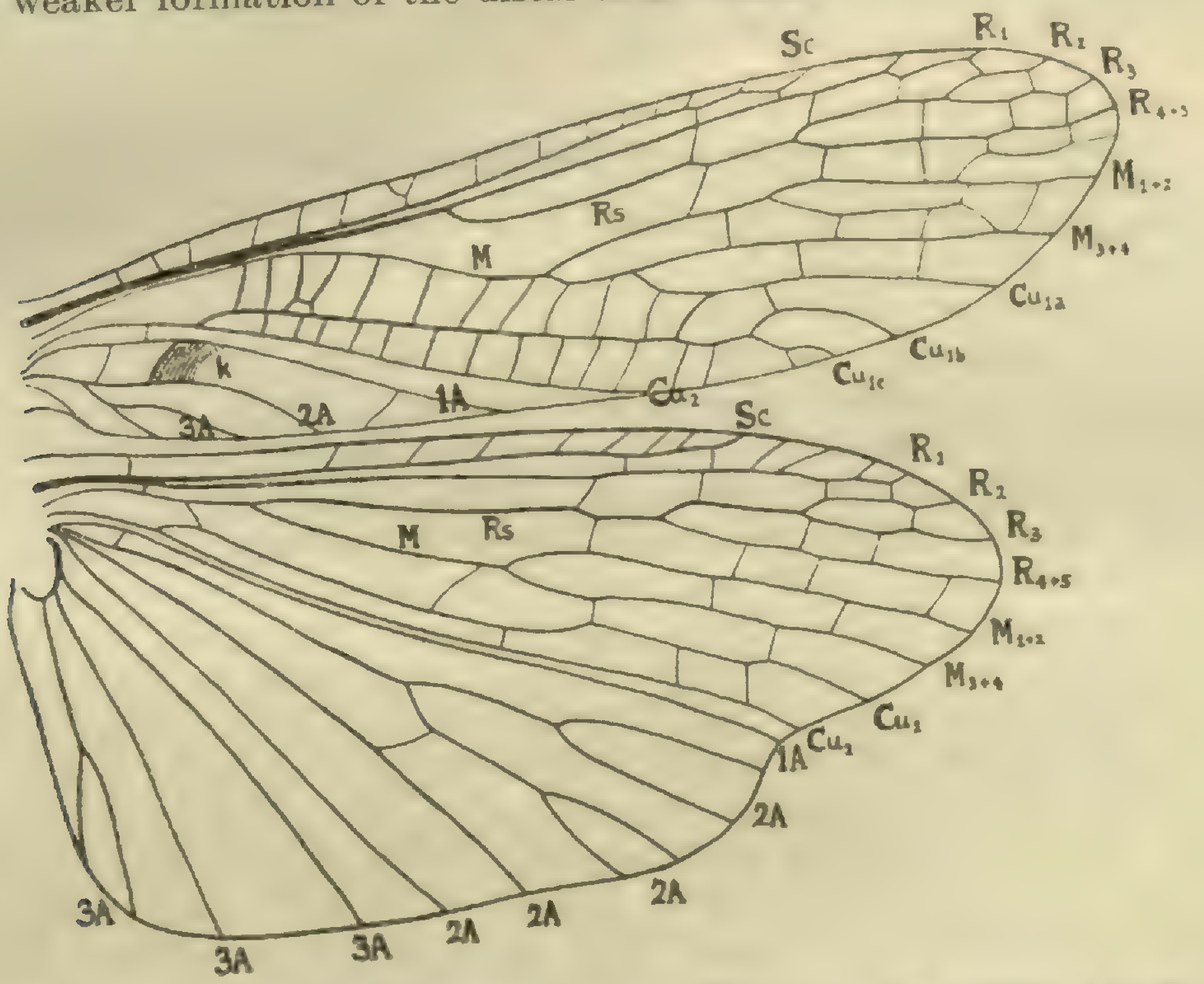


FIG. 2.—Wing-venation of *Austroperla cyrene* (Newm.). (For lettering see fig. 1, except *k*, the strongly thickened second inter-anal cross-vein.)

Austroperla cyrene (Newman). (Fig. 2.)

Chloroperla cyrene Newman, 1845, *Zoologist*, vol. 3, p. 853. *Perla* (?) *cyrene* Walker, 1852, *Cat. Neur. Brit. Mus.*, p. 168; McLachlan, 1874, *Trans. N.Z. Inst.*, vol. 6, App., p. xcii (genus undet.). *Stenoperla* (?) *cyrene* Hutton, 1899, *Trans. N.Z. Inst.*, vol. 31, p. 212. *Heteroperla cyrene* Hare, 1910, *Trans. N.Z. Inst.* vol. 42, p. 30.

Type in British Museum collection.

This common species varies greatly in size, specimens being found with an expanse from 20 mm. up to 30 mm. It may readily be distinguished by its folding the wings rather flatly down above its abdomen, with much less rolling of them around the body than in the Leptoperlidae, and also by its striking colour-pattern. The whole of the body is black, the wings blackish with weakly formed distal cross-venation, the forewing with a conspicuous cream-coloured humeral patch, which is continued more or less clearly as a pale stripe along part or whole of the costa. The legs are black, but the tibiae have a broad band of pale yellow occupying more than half their length. Cerci short.

It is of interest to note that a species of *Tasmanoperla* existing in Victoria, but not yet described, has a coloration closely similar to this species. There is also to be found in Otago a species of *Zelandoperla*, not yet described, which closely resembles it in coloration, but can be at once distinguished by its much longer cerci, as well as by its very different venational characters.

The larvae are very sluggish creatures, and frequently congregate at the edges of streams, under moist rocks or in wet trash, where other stone-fly larvae would not be able to exist. They are also unique in being able to stand removal from their natural habitat and living for quite a long time under abnormal conditions, even withstanding a considerable degree of desiccation. Probably they breathe through the integument generally, and perhaps also by means of gills placed internally within the anal opening.

Family LEPTOPERLIDAE.

This family was first recognized as a distinct group by Newman in 1839, and has been raised to tribal rank by N. Banks under the name Leptoperlini, these authors not considering the whole of the Perlaria to be entitled to more than family rank. Now that the ordinal rank of the Perlaria is well established, the various tribes of N. Banks take family rank. Enderlein in 1909 formed the family Gripopterygidae to include the whole of the Leptoperlidae, Austroperlidae, and Eustheniidae as here defined, but, curiously enough, omitted the genus *Leptoperla* Newman from his keys and lists of genera. The family name which he adopted was taken from the genus *Gripopteryx* Pictet, 1841. As Newman recognized *Leptoperla* as belonging to a distinct group, even though, at that time, he placed only one genus (*Leptoperla*) in it, I think Banks was right in choosing the name Leptoperlini for his tribe, and Enderlein wrong in selecting a new name, Gripopterygidae, for his family, when he might have called it Leptoperlidae. I have therefore followed Newman and Banks in preference to Enderlein, and have named the family Leptoperlidae in a paper published in *Canadian Entomologist*, February, 1921, pp. 35–40. It should be noted that Enderlein's family is a composite one, and that when, in another paper, he subdivided it, he placed a portion of the true Leptoperlidae within the subfamily Gripopteryginae, together with the whole of the Eustheniidae and Austroperlidae, while another portion was placed in the subfamily Antarctoperlinae. This curious classification was brought about by selecting as the primary characters for subdivision the forked or simple condition of Rs and Cu_1. A careful study of the whole group reveals the fact that two genera so closely allied as to agree in almost every character may differ only in one having Rs forked and the other having it simple—*e.g.*, the

closely allied New Zealand genera *Zelandobius* and *Nesoperla*, which would have been placed by Enderlein in two distinct subfamilies, thus completely ignoring their true relationship to one another.

The Leptoperlidae are the dominant family of stone-flies in the southern portion of South America, in New Zealand, Tasmania, and Australia. Their larvae are common objects in fast-running streams, being found clinging to rocks where the water runs fastest. They are mostly sluggish creatures, and do not attempt to run away fast, like the larvae of *Stenoperla* and may-flies. The imagines fly but little, but may be found resting, with their wings rolled closely around their bodies, either on rocks or foliage near streams.

In order to classify the New Zealand species I have undertaken a comprehensive study of the whole family. New Zealand and Australia are both rich in species, and the faunas of the two countries are so closely allied that they had to be treated as a single whole. The final result of this study, as far as it can be carried out on the available material, goes to show that a number of closely allied genera exist in the two countries, but that no single genus is found both in Australia and New Zealand. *Leptoperla* Newman is confined to Tasmania. *Leptoperla opposita* Walker, to which there are a number of references by New Zealand authors, all of whom, following McLachlan, express a doubt as to whether this is really a New Zealand insect, is not found in New Zealand, and proves not to be congeneric with *Leptoperla beroë* Newman, which is the type of *Leptoperla* Newman; it is confined to Australia. In a recent paper (*Canad. Entom.*, Feb., 1921, p. 43) I have made *L. opposita* the type of a new genus, *Dinotoperla*. Another Australian genus, *Paranotoperla* Enderlein, also proves not to be represented in New Zealand. Thus the way is clear for the correct classification of the New Zealand species in the present paper, while the working-out of the rather numerous generic types from Australia is kept for a later publication.

As the species described by Enderlein from the Auckland Islands is very closely allied to one of the New Zealand genera, I propose to include it in the key given below.

To the characters given for the family Leptoperlidae in the key we may now add the following:—

In the forewing the three anal veins are present, but 3A is fused with 2A for the whole of its basal half, and its free distal end appears only as a short veinlet descending from 2A. In my paper on the "Classification of the Perlaria" (*Canad. Entom.*, Feb., 1921, pp. 35–40) I interpreted this formation to mean that only two anal veins were present in this family, 1A having been eliminated. The tracheation of the larval wing shows, however, that this is not the case. 1A is present, and is the vein named 2A in the paper just quoted. Tracheae 2A and 3A are both present in the larval wing, though the corresponding veins are fused together in the imago for a considerable distance. A closely similar formation is to be seen in the forewing of Nemouridae, and has been clearly elucidated by Comstock (see *The Wings of Insects*, 1918, pl. 1).

In the hindwing there is always either a complete or a partial fusion of M_{3+4} with Cu_1. This condition would not be suspected from a study of the imago alone, but can be clearly seen by examining the tracheation of the larval hindwing. A similar condition has been shown to exist in certain genera of Perlidae by Comstock.

Key to the Genera of Leptoperlidae found in New Zealand and the Auckland Islands.

1	Radial sector in both wings forked; hindwing with the fusion between M_{3+4} and Cu_1 incomplete	2
	Radial sector in both wings simple; hindwing with the fusion between M_{3+4} and Cu_1 complete	3
2	Fork of Rs long and well developed	*Megaleptoperla* n. g.
	Fork of Rs short, terminal	*Zelandobius* Till.
3	Forewing distinctly longer than hind	4
	Forewing shorter than the hind	*Aucklandobius* End.
4	No pterostigmatic veinlets in either wing; forewing without cross-veins below the distal portion of Cu_1	*Nesoperla* n. g.
	A set of pterostigmatic veinlets present in both wings; forewing with cross-veins descending from the whole length of Cu_1	*Zelandoperla* n. g.

Of the genera given in the above key, *Aucklandobius* End. is confined to the Auckland Islands, and is represented by a single species, *A. complementarius* End. The other three genera are found only in New Zealand.

Genus Megaleptoperla n. g. (Fig. 3.)

To the characters given in the above key we may add the following: Insects of moderate to large size, from 1 in. to over 2 in. in expanse. *Forewing* narrow, three and a half times as long as wide; Sc lying close alongside R_1 for its whole length and forking at its tip; Cu_1 ending up about half-way between end of Cu_2 and apex of wing; 1A very close to Cu_2; only one inter-anal cross-vein connecting 1A with 2A. Both wings with a set of pterostigmatic veinlets present.

Genotype.—Leptoperla grandis Hudson.

Megaleptoperla grandis (Hudson). (Figs. 3, 4.)

Leptoperla grandis Hudson, *Trans. N.Z. Inst.*, vol. 45, p. 51, 1913.

Hudson's description deals only with the size and coloration of this species, and fails to mention any of the very striking features of the venation, which separate it at a glance from all other described Perlaria. To the details already given in the generic key and definition the following specific characters may now be added:—

Head 3 mm. wide across the eyes, which are nearly black, but only 1·7 mm. long inclusive of the projecting clypeal shelf, which is itself only about half as wide as the rest of the head. Ocelli small but prominent: antennae with large bases set well forward in front of the eyes, the two basal segments considerably enlarged, the rest cylindrical, slightly hairy. Mouth-parts yellowish-brown, the palpi rather short.

Thorax: Pronotum sub-trapezoidal, 2 mm. long by 2·5 mm. wide, slightly wider behind than in front; the hinder edge with a narrow raised rim, as shown in fig. 4; median longitudinal furrow present but weakly formed. Meso- and meta-notum with a pale-yellowish median longitudinal band. Legs: Fore tibiae marked alternately with two transverse bands of dark fuscous and two of pale testaceous; hind legs with numerous soft hairs.

Abdomen: In the male the last two segments are paler than the rest, rich brown. The appendages are strongly curved and turn upwards behind the tenth tergite; viewed laterally their ends are flattened and well rounded; viewed from behind they are close together at their bases, but diverge apically, their tips appearing sharply pointed; the small copulatory

hook projects upwards between them but is considerably shorter. Cerci 3 mm. long, with numerous small ring-like segments, yellowish-brown with abundant short hairs.

Wings: Specific characters in the wing-venation are the presence of a complete series of costal veinlets in the forewing, and the very regular and complete formation of the distal cross-veins in both wings, associated with a certain amount of zigzagging of the branches of Rs and M_{1+2}. The mottled grey and whitish colouring of the forewing is continued on the distal two-thirds of the costa of the hindwing, including the pterostigma; the rest of the hindwing is whitish-subhyaline.

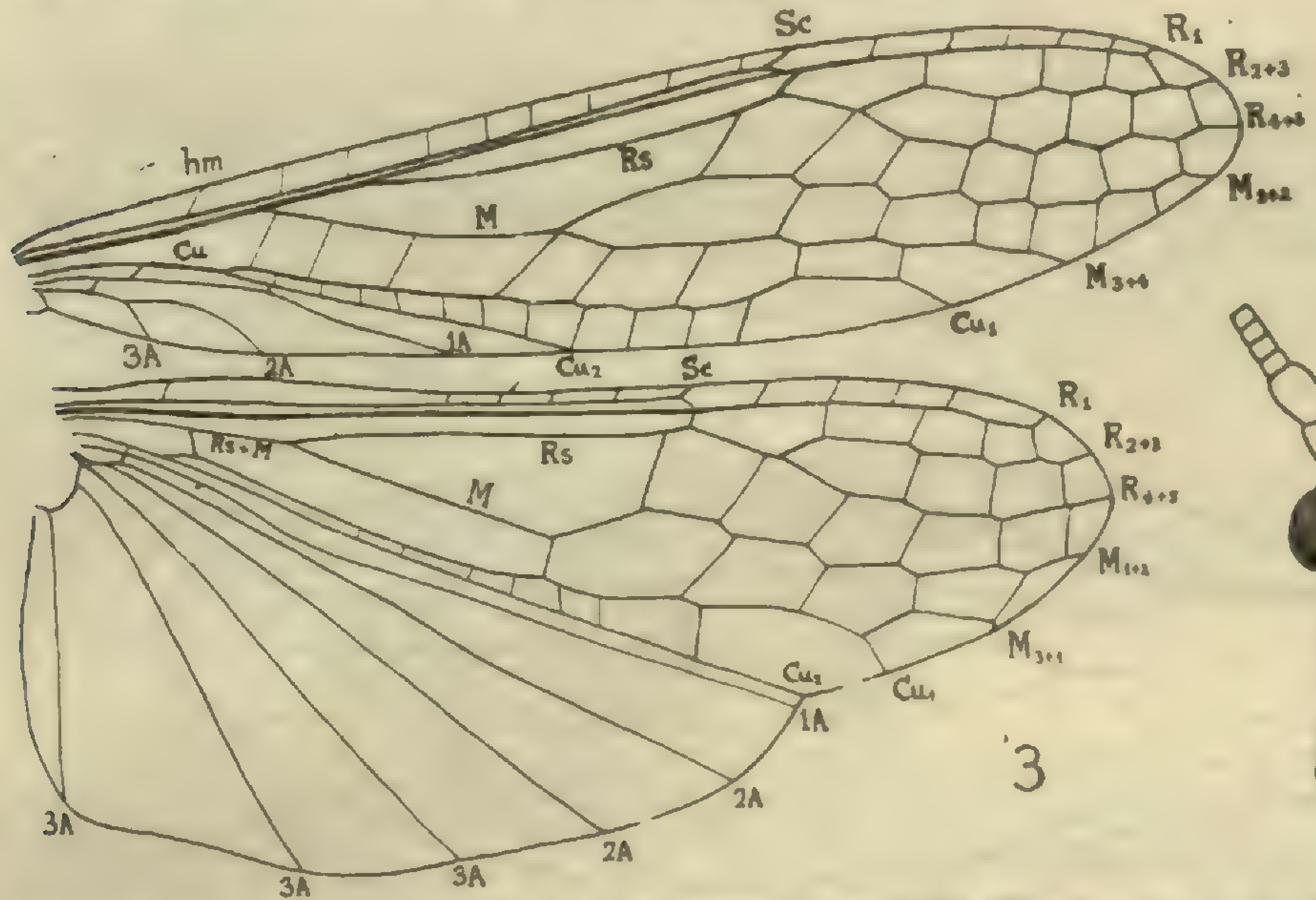


FIG. 3.—Wing-venation of *Megaleptoperla grandis* (Hudson) n. g. (For lettering see fig. 1.)
FIG. 4.—Head and pronotum of *Megaleptoperla grandis* (Hudson), ♂ (× 4·4).

Type in Mr. G. V. Hudson's collection; sex not specified.

Locality.—The type specimen was taken near Ohakune. Other localities for it are Tokaanu, Lake Taupo, where the larva is not uncommon under rocks in the Tongariro River (R. J. T.); Arthur's Pass and Dunedin (W. G. Howes).

Genus ZELANDOBIUS Tillyard. (Figs. 5, 8.)

Tillyard, *Canadian Entomologist*, Feb., 1921, p. 43.

To the characters given in the key we may add the following: Insects of small size, under 1 in. in expanse. Both wings with or without extra costal veinlets besides the humeral; pterostigma without veinlets; fork of Rs very short, terminal, usually without cross-veins, but sometimes with a single one as shown in fig. 6, forewing. Distal cross-veins irregularly placed, not very numerous; in forewing a complete series below Cu_1 right to its end, and only a single inter-anal connecting 1A with 2A. Sc not terminally forked, but with its apex turned upwards to the costa, and a cross-vein descending on to R_1 some little way before the apex.

Genotype.—Leptoperla confusa Hare.

Several species of this genus occur in New Zealand. Hare has described two species, both under *Leptoperla*—viz., *Z. confusus* (Hare), and *Z. hudsoni* (Hare).

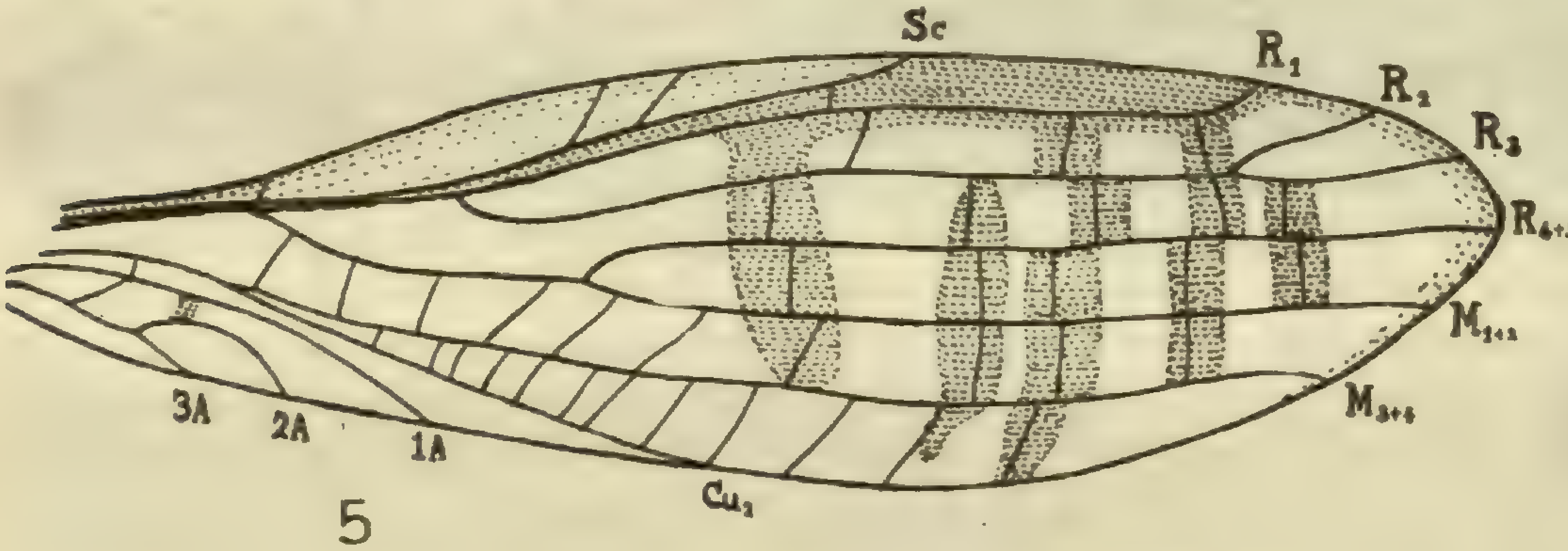
Key to the Species of the Genus Zelandobius.

1	Forewings unicolorous, pale-brownish	*Z. unicolor* n. sp.
	Forewings fuscous, with darker markings	2
2	Markings of forewing tending to become confluent in transverse bands and broadly enveloping the distal cross-veins ..	*Z. confusus* (Hare).
	Markings of forewing remaining as distinct fuscous shadings of the distal cross-veins, merely outlining but not broadly enveloping them	3
3	Cerci as long as abdomen; terminal fork of forewing arising before level of end of R_1	*Z. hudsoni* (Hare).
	Cerci excessively short; terminal fork of forewing arising at or beyond level of end of R_1	*Z. furcillatus* n. sp.

Zelandobius confusus (Hare). (Fig. 5.)

Leptoperla confusa Hare, *Trans. N.Z. Inst.*, vol. 42, p. 29, 1910.

Fig. 5 shows the venation and pattern of the forewing of a female, the length of the wing being 9·5 mm. This figure well exemplifies the character mainly relied upon by Hare to discriminate this species—viz., the arrangement of the distal cross-veins ("posterior veinlets" of Hare) "in distinct



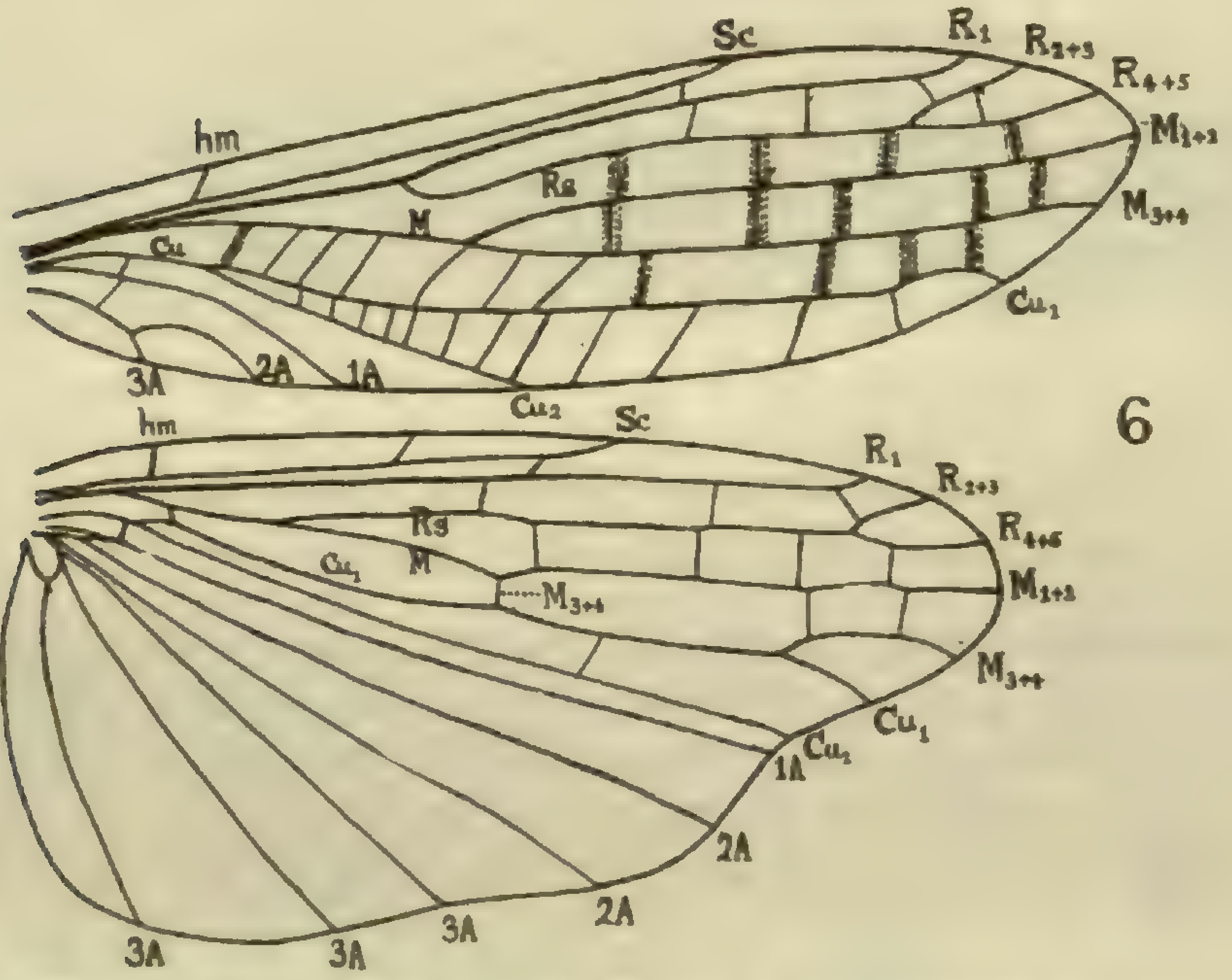


FIG. 5.—Wings of *Zelandobius hudsoni* (Hare). (For lettering see fig. 1.)
FIG. 6.—Forewings of *Zelandobius confusus* (Hare). (For lettering see fig. 1.)

series, the grey markings about the veinlets of each series being confluent, and not in the form of distinct spots." It should be added, however, that the number and position of the cross-veins is not constant, so that there is some variability in the form of the pattern, though the confluence of

markings is always more or less marked. The specimen figured had three extra costal veinlets besides the humeral on the left forewing, but only two on the right. The pterostigmatic region is shaded and stands out quite conspicuously. The cerci, not mentioned by Hare, are short—only about 1·2 mm. long.

Type in Mr. Hare's collection.

Locality.—Karori, Wellington. I have also seen a series taken by Mr. H. Hamilton on Mount Hector, 16th February, 1921.

Zelandobius hudsoni (Hare). (Fig. 6.)

Leptoperla hudsoni Hare, *Trans. N.Z., Inst.*, vol. 42, p. 30, 1910.

Fig. 6 shows both wings of this species, the forewing of which is about 8 mm. long.* The costal margin of the forewing is straight, not curved as in *Z. confusus* (Hare), and there are no extra costal veinlets beyond the humeral. The distal cross-veins are placed quite irregularly, and are very distinct, each one being separately outlined with fuscous. There is a complete series of cross-veins below Cu_1 in forewing, right to its tip. The cerci are as long as the abdomen.

Type in Mr. Hare's collection.

Locality.—Karori, Wellington. I have never taken this species, which can be at once distinguished from all other species of the genus by its much longer cerci.

Zelandobius furcillatus n. sp. (Fig. 7.)

This common little species bears a strong superficial resemblance to *Z. hudsoni* (Hare), but can at once be distinguished from it by the following characters: Antennae blackish, moniliform, in male as long as forewing, in female shorter. Terminal fork of Rs in both wings exceedingly short, arising beyond the level of the end of R_1, or, much more rarely, directly under the end of R_1. Intercubital series of cross-veins not continued beneath the whole or greater part of the length of Cu_1 in forewing, but ending up either at end of Cu_2 or a little beyond it. Costal space of forewing with

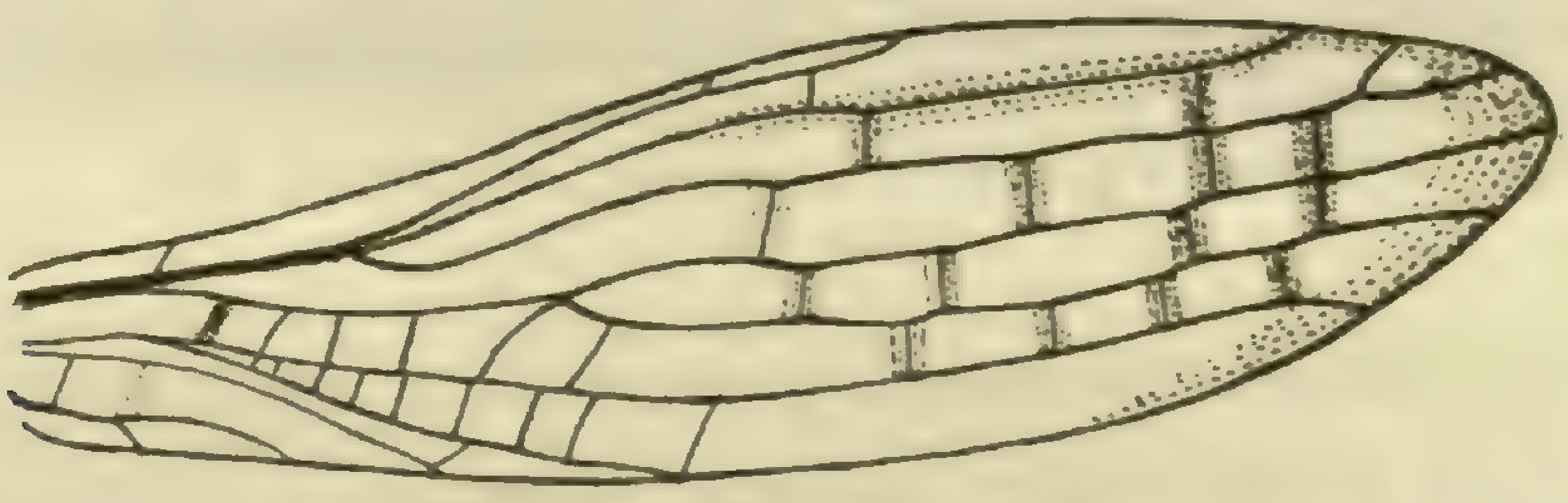


FIG. 7.—Forewing of *Zelandobius furcillatus* n. sp.

a small extra veinlet besides the humeral; this veinlet placed well distad along Sc. Cerci very short, about 0·3 mm. long, with only five or six segments. Male with short upturned appendages. Female with subgenital plate strongly bilobed. Forewing of male 7 mm., of female 8·5 mm. long.

Types.—Holotype male and allotype female in Cawthron Institute collection (Tarawera; male 16th November, female 15th November, 1919; R. J. T.).

* In my paper in *Canadian Entomologist*, February, 1921, text-fig. 4c, p. 42, I inadvertently figured the forewing of this species under the name *confusus*.

Locality.—Common in many parts of New Zealand: Rotorua, Tarawera, Taupo; also Cass and Kingston (R. J. T.). Probably generally distributed.

Zelandobius unicolor n. sp. (Fig. 8.)

Resembles the preceding species in having the short extra distal veinlet in the costal space of the forewing, and in the excessive shortness of the terminal fork, which arises below the end of R_1, but differs from it in being a more robust insect, of somewhat larger size (forewing 9 mm.), with broader wings, of very different coloration, and with the antennae not so definitely moniliform, pale-brownish at base, darkening towards apex. Forewing subhyaline, tinged with pale-brownish, and along the costa with

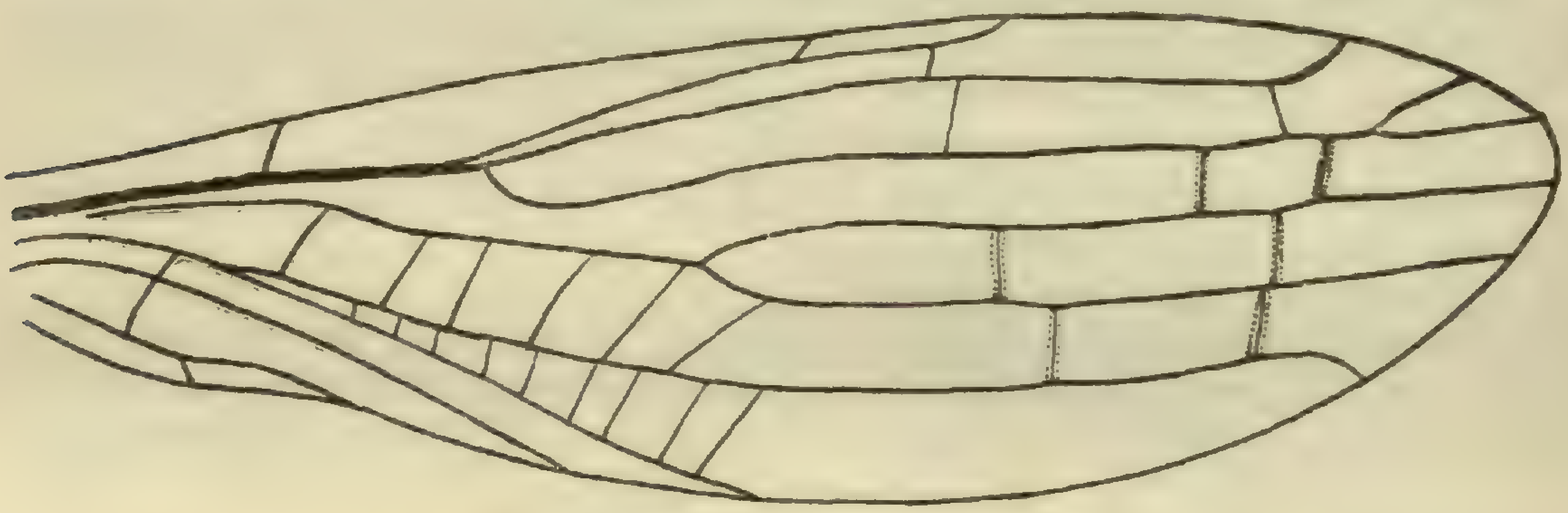


FIG. 8.—Forewing of *Zelandobius unicolor* n. sp.

a suspicion of rose-pink; the veins yellowish-brown. Hindwing hyaline with the faintest tinge of yellowish-brown. The intercubital series of cross-veins in the forewing does not go beyond the end of Cu_2, and there are very few distal cross-veins, only two (rarely three) between each pair of main veins, as shown in fig. 9; those between Rs and M_{1+2}, M_{1+2} and M_{3+4}, M_{3+4} and Cu_1 respectively are very faintly shaded with pale fuscous. Cerci excessively short.

Type.—Holotype, apparently a male (abdomen shrivelled), in Cawthron Institute collection.

Locality.—Arthur's Pass, 18th January, 1920 (R. J. T.).

Genus NESOPERLA n. g. (Figs. 9, 10, 12.)

Insects of medium size, somewhat larger than those comprised in *Zelandobius* Till. Radial sector simple in both wings. Costal space with no extra veinlets beyond the humeral. Pterostigma without any veinlets. In the forewing the series of cross-veins below Cu_1 is incomplete distally. Hindwing with the fusion between M_{3+4} and Cu_1 complete.

Genotype.—*Leptoperla fulvescens* Hare.

This genus differs from *Zelandobius* Till. in having Rs simple in both wings, in having the fusion between M_{3+4} and Cu_1 complete in the hindwing, and in not possessing any extra veinlets in the costal space. It differs from *Zelandoperla* n. g., to which it is very closely allied, by not having any pterostigmatic veinlets, and by the distal series of cross-veins in the forewing below Cu_1 being absent from the distal part of the area in question.

KEY TO THE SPECIES OF THE GENUS NESOPERLA.

1	Forewings unicolorous semitransparent brownish	2
	Forewings with a definite pattern of alternating light and dark areas	3
2	Larger species (forewing 13 mm.) with large reddish-brown pronotum, the posterior lateral corners of which are rounded in the female. (Male unknown)	*N. howesi* n. sp.
	Smaller species (forewing 11·5 mm.), of slenderer build, with smaller blackish pronotum, the posterior corners of which are produced into two prominent spines in the male and cut off at right angles in the female	*N. spiniger* n. sp.
3	Forewings greyish ochreous, each distal cross-vein surrounded by a small pale subhyaline area	*N. fulvescens* (Hare).
	Forewings brownish or fuscous, with three (more rarely only two) large subhyaline areas extending irregularly across the wing at wide intervals	*N. trivacuata* n. sp.

Nesoperla fulvescens (Hare). (Fig. 9).

Leptoperla fulvescens Hare, *Trans. N.Z. Inst.*, vol. 42, p. 29, 1910.

The venation and pattern of the forewing of this very striking species are shown in fig. 9. Besides the very characteristic formation whereby the distal cross-veins are isolated within pale subhyaline areas, there is also a larger irregular area of the same kind reaching from the basal portion of Rs across the fork of M and across Cu_1 to end on the apex of Cu_2; this area varies somewhat in different specimens, but is roughly triangular, its base being on Rs and its apex on Cu_2. There is a complete set of distal cross-veins between M_{3+4} and Cu_1, but the intercubitals do not continue quite to the end of Cu_1.

Type in Mr. Hare's collection.

Locality.—Karori, Wellington. I have not taken this species.

Nesoperla howesi n. sp. (Figs. 10, 11 *a, c.*)

♀. Forewing, 13 mm.; hindwing, 11 mm.; expanse, 27·5 mm.

Head rich reddish-brown, except for the triangular space between the ocelli, which is blackish, and a narrow bar of blackish running from each lateral ocellus to the compound eye. Eyes very dark brown. Antennae 9 mm. long, yellowish-brown, pubescent, with a few longer delicate hairs.

Thorax: Pronotum rich brown, 1·7 mm. long by 2·2 mm. wide, shaped as shown in fig, 11, *a*, the posterior lateral corners being well rounded. Meso- and meta-notum black. Legs brown, the middle femora darkened beneath.

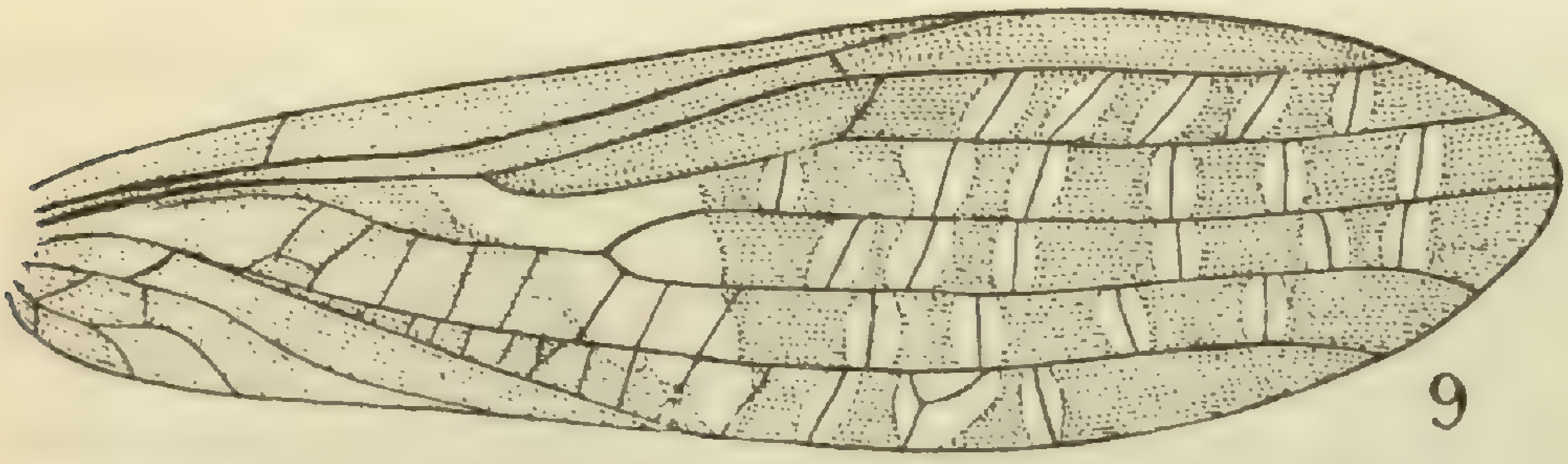
Abdomen black, touched with reddish-brown on sides; segment 10 rich brown. Ventral plate projecting in the form of a semi-oval lobe, rather narrow, covered with fine hairs (fig. 11, *c*). Cerci 3·5 mm. long, brown.

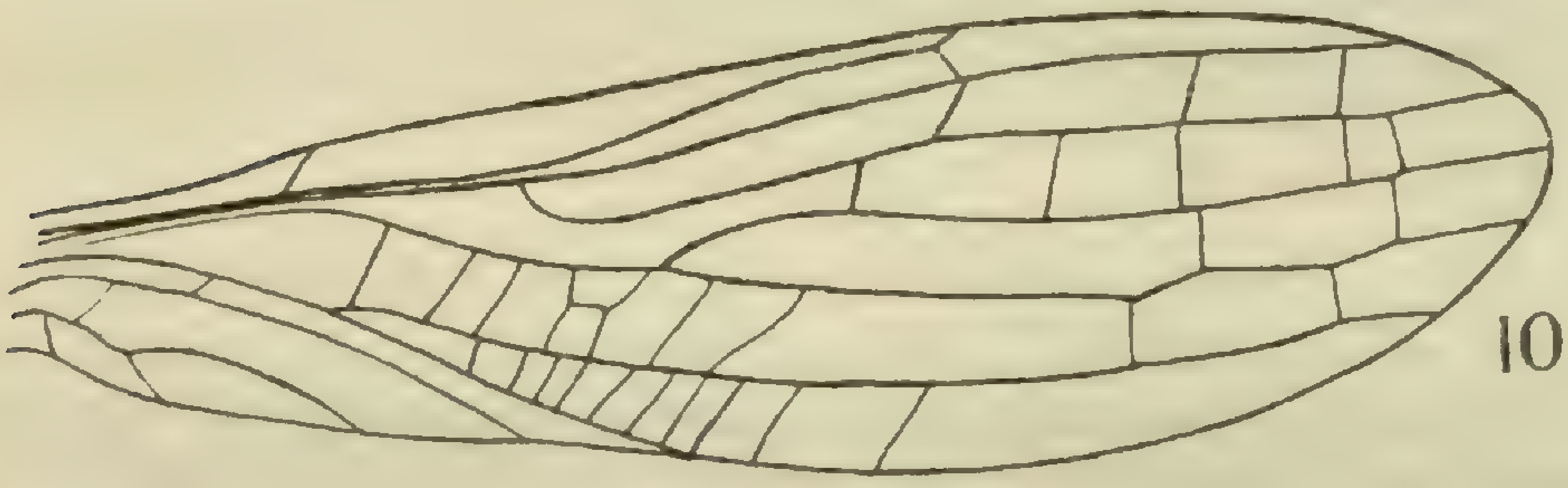
Wings: Forewing a unicolorous semitransparent brownish-testaceous, in life very bright and having a distinctly reddish tinge; the veins slightly darker. Hindwing paler, more inclined to greyish except along costa, which remains brownish. Venation of forewing as shown in fig. 10, with Sc forked at its apex (contrast the form of apex of Sc in forewing of *N. fulvescens*—fig. 9), few distal cross-veins irregularly placed, only two between M_{3+4} and Cu_1 instead of a complete set as in *N. fulvescens*, and a long space distally below Cu_1 without cross-veins.

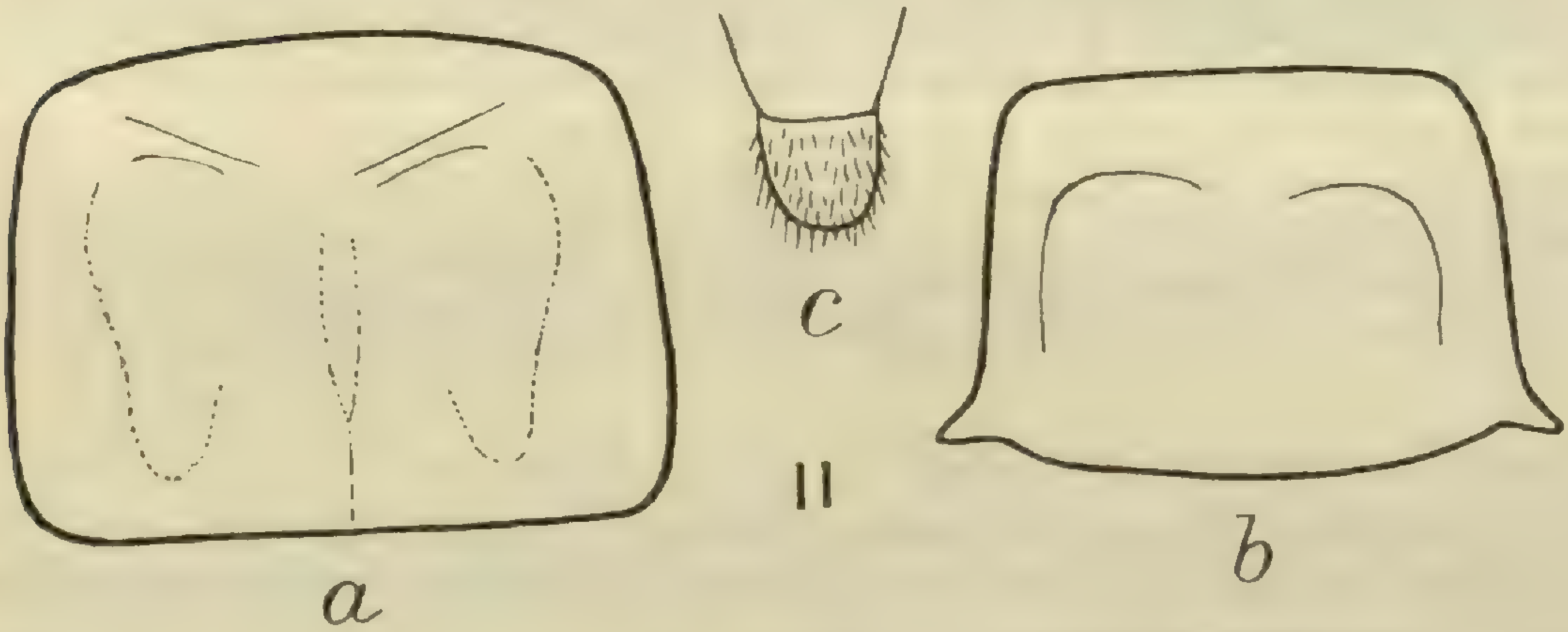
Type.—Holotype female, unique, in Cawthron Institute collection.

Locality.—Arthur's Pass, female, 18th January, 1920 (R. J. T.).

In life this was a very striking species, its rich reddish-brown colour and unicolorous wings marking it out clearly from all the rest, including the closely allied following species.







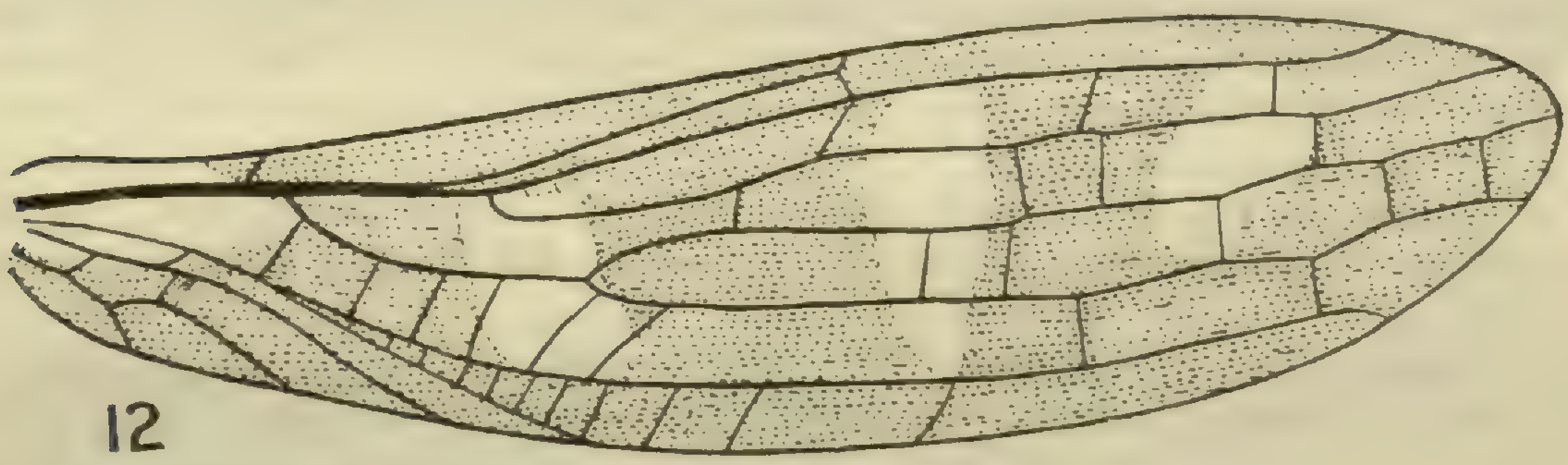


Fig. 9.—Forewing of *Nesoperla fulvescens* (Hare), n. g.
Fig. 10.—Forewing of *Nesoperla howesi* n. g. et sp., ♀
Fig. 11.—*a*, pronotum of *Nesoperla howesi* n. sp., ♀, outline (× 12); *b*, pronotum of *Nesoperla spiniger* n. sp., ♂, outline (× 12): *c*, ventral plate of *Nesoperla howesi* n. sp., ♀ (× 20).
Fig. 12.—Forewing of *Nesoperla trivacuata* n. g. et sp.

Nesoperla spiniger n. sp. (Fig. 11*b*.)

♂. Forewing, 11·5 mm.; hindwing, 9·5; expanse, 24 mm.

General appearance not unlike that of the preceding species, but a smaller and much slenderer insect, with duller unicolorous brown coloration.

Epicranium and pronotum blackish, the latter 1·4 mm. long by 2 mm. wide, and having the posterior lateral corners produced into two strong projecting spines (fig. 11, *b*). Appendages strongly upcurved, sharply pointed, with the shorter copulatory hook lying between them and having a narrowly blunt apex. Venation closely similar to that of *N. howesi* n. sp.

Female closely similar in size and general appearance to male, but having the posterior lateral corners of the pronotum cut off sharply at right angles, thus differing from those of *N. howesi* n. sp., which are rounded. Abdomen much slenderer than in *N. howesi*, reddish-brown in colour, darkest at base, and becoming bright-reddish apically. Ventral plate much less prominent than in *N. howesi* n. sp.

Types.—Holotype female, allotype male, and series of six paratype males in Cawthron Institute collection. (Holotype and allotype, 18th January, 1920, Arthur's Pass; R. J. T.)

Locality.—Arthur's Pass, January, 1920; taken both by Mr. Howes and myself.

Nesoperla trivacuata n. sp. (Fig. 12.)

♂. Forewing, 8·5 mm.; hindwing, 7 mm.; expanse, 18 mm.

In this species the head, thorax, and abdomen are all brownish-black, the pronotum having a definite median longitudinal impressed line on it. The pattern of the wings is very distinctive, as can be seen from fig. 12. The ground-colour of the forewing is either fuscous or brownish, and is interrupted by three large irregular areas, arranged more or less transversely at wide intervals across the wing, these areas being very pale and subhyaline. There is also sometimes a pale area of irregular shape close to the base. The size and shape of each of the three subhyaline patches varies greatly in different specimens: sometimes they are more or less oval, with fairly regular outline; sometimes more like transverse fasciae, with irregular outline. The typical and most common form has them very much as shown in fig. 12. Legs a bright medium brown. Cerci 3 mm., brownish. Appendages short, dark, slightly upcurved.

♀. Forewing, 11 mm.; hindwing, 9 mm.; expanse, 23 mm.

Closely resembling the male, but larger; forewings more fuscous. (Abdomen shrivelled, so that ventral plate cannot be seen.)

Types.—Holotype male (Lake Rotorua, 18th November, 1919; R. J. T.), allotype female (Tokaanu, Lake Taupo, 24th November, 1919, R. J. T.), and series of paratypes in Cawthron Institute collection.

Locality.—Appears to be generally distributed throughout New Zealand, but commonest in the North Island.

Varieties.—A variety frequently occurs in which the most basal of the three subhyaline patches is either obsolescent or quite absent. In one specimen this and the middle patches have coalesced.

Genus AUCKLANDOBIUS End.

Enderlein, *Deutsche entom. Zeitung*, 1909, pp. 680–82.

Closely allied to *Nesoperla* n. g., but differing from it in having the forewing distinctly shorter than the hindwing, and the cerci longer than the abdomen.

Genotype.—*A. complementarius* End.

This genus is remarkable in the shortening of the forewing without any corresponding shortening of the hindwing. There are a number of instances known in the Perlaria in which certain species undergo reduction

of both wings, the hindwings remaining all the time shorter than the forewings, and the venational scheme persisting. It would appear as if the Auckland Islands had been originally colonized by a species of *Nesoperla* long ago, and that the shortening of the forewing and lengthening of the cerci had both been brought about in response to the restricted insular condition.

Aucklandobius complementarius End.

Enderlein, *Deutsche entom. Zeitung*, 1909, pp. 681–82, figs. 1, 3.

It is not necessary to add anything to Enderlein's excellent description, with figures of the venation and the ventral plate of the female.

Types in Dresden and Stettin Zoological Museums. Collected by Professor H. Krone (two males, one female).

Locality.—Auckland Islands.

Genus ZELANDOPERLA n. g. (Figs. 13, 15, 16.)

Insects of medium to fairly large size. Radial sector simple in both wings. Costal space with no extra veinlets beyond the humeral. Pterostigma with a complete series of veinlets in both wings. In the forewing the series of cross-veins below Cu$_1$ is complete distally. Hindwing with the fusion between M$_{3+4}$ and Cu$_1$ complete.

Genotype.—*Zelandoperla decorata* n. sp.

As already stated under *Nesoperla* (*q.v.*), this genus is very closely allied to *Nesoperla*, but can be at once distinguished from it by the presence of the complete set of pterostigmatic veinlets in both wings, and also by the complete series of distal cross-veins below Cu$_1$ in the forewing. The pattern of the forewings in all species is much variegated.

KEY TO THE SPECIES OF ZELANDOPERLA.

1	Distal half of forewing hyaline, with dark-fuscous markings around the cross-veins	2
	Distal half of forewing brownish-fuscous, with hyaline patches situated in between the cross-veins	*Z. fenestrata* n. sp.
2	Large, robust species, heavily marked with dark fuscous; each distal cross-vein enclosed in a dark almost circular patch	*Z. decorata* n. sp.
	Smaller and slenderer species, less heavily marked with dark fuscous; each distal cross-vein enclosed in a much smaller suboval patch	*Z. maculata* (Hare).

Zelandoperla decorata n. sp. (Figs. 13, 14*a*.)

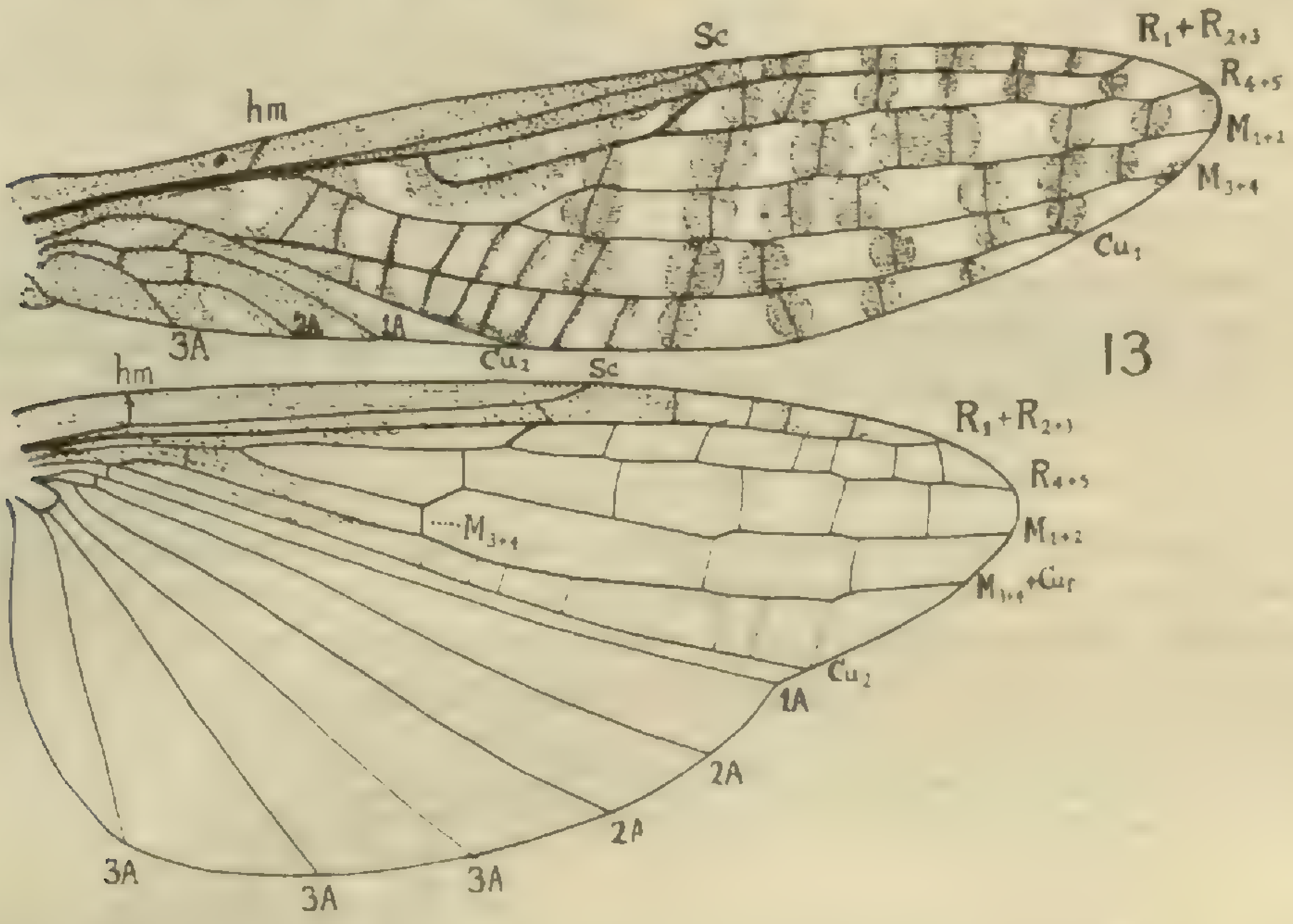
♀. Forewing, 14·5 mm.; hindwing, 12·5 mm.; expanse, 30·5 mm.

Head short and wide, dull black, with pale-greyish pubescence. Median ocellus very small, the two lateral ocelli much larger, ruby-red, set on large black tubercles. Eyes, antennae, and mouth-parts dark brown. Behind the ocelli there is a transverse band of dark brown from eye to eye. Antennae 10 mm. long, basal segments very strong and large, second segment much smaller, but considerably larger than the others (fig. 14*a*).

Thorax.—Pronotum 1·5 mm. long by 1·9 mm. wide, with well-defined anterior, posterior, and median longitudinal grooves, the last-named slightly widened in the middle; colour dull black, with greyish-white pubescence (fig. 14*a*). Meso- and meta-notum shining black, with very slight pubescence. Legs dull brown to blackish, with soft pale hairs; femora mostly brown, with two patches of blackish, one at apex and one a little before; tibia with a black patch at base, followed by a pale-brownish

portion which rapidly darkens distally to chocolate-brown and occupies two-thirds of the length of the whole segment; tarsi deep fuscous.

Abdomen shining black, with pale yellowish-brown pubescence and longer, softer hairs of a greyish-white colour on either side of the segments. Ventral plate entire, very slightly convex. Cerci 4 mm. long, downy, deep fuscous, the segments numerous and very short.



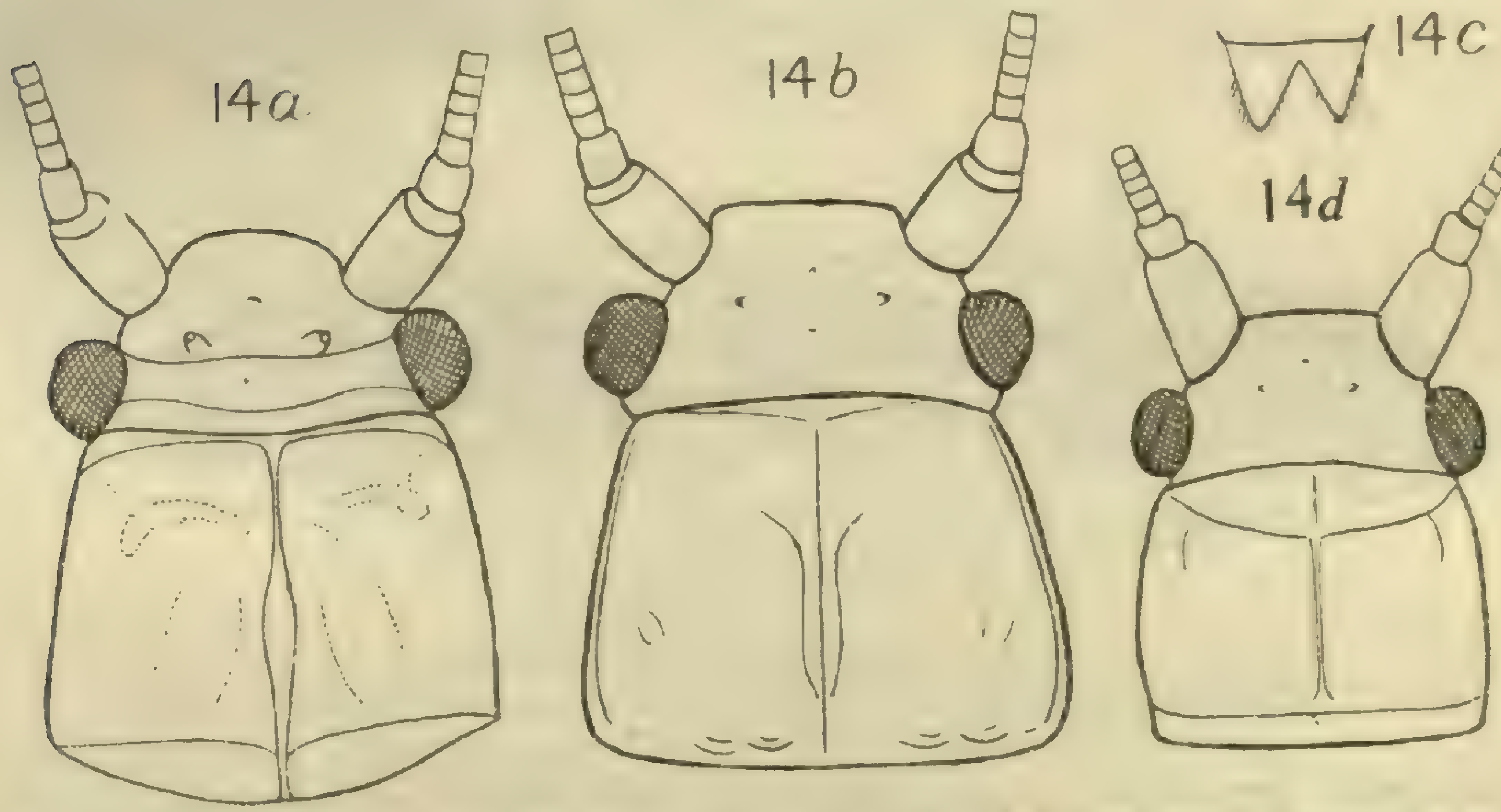


FIG. 13.—Wing-venation and colour-pattern of wings of *Zelandoperla decorata* n. g. et sp. (For lettering see fig. 1.)

FIG. 14.—*a–c*, heads and pronota of species of the genus *Zelandoperla* n. g. (× 16). *a*, *Z. decorata* n. sp., ♀; *b*, *Z. fenestrata* n. sp., ♀; *c*, ventral plate of *Z. fenestrata* n. sp., ♀ (× 16); *d*, *Z. maculata* (Hare), ♂.

Wings pale greyish-subhyaline. Forewing richly marked with dark fuscous as follows: the whole of the basal fourth, except a clear patch below *hm* and another between 2A and 3A, and the whole of the costal and subcostal spaces to the end of Sc. Medio-cubital and intercubital cross-veins outlined with dark fuscous; the whole of the pterostigmatic and distal series enclosed in large fuscous patches, which in the case of the distal series are circular or nearly so in outline. Hindwing marked with

fuscous for basal fourth of costal space and also around pterostigmatic veinlets; the basal third of cubital space also marked in the same way. Venation very dark brown (fig. 13).

Types.—Holotype female and three paratype females in Cawthron Institute collection. (Holotype, Arthur's Pass, 16th January, 1920; R. J. T.).

Locality. Arthur's Pass, January, 1920; taken by Mr. Howes and myself. Mount Egmont, 29th February, 1920 (R. J. T.).

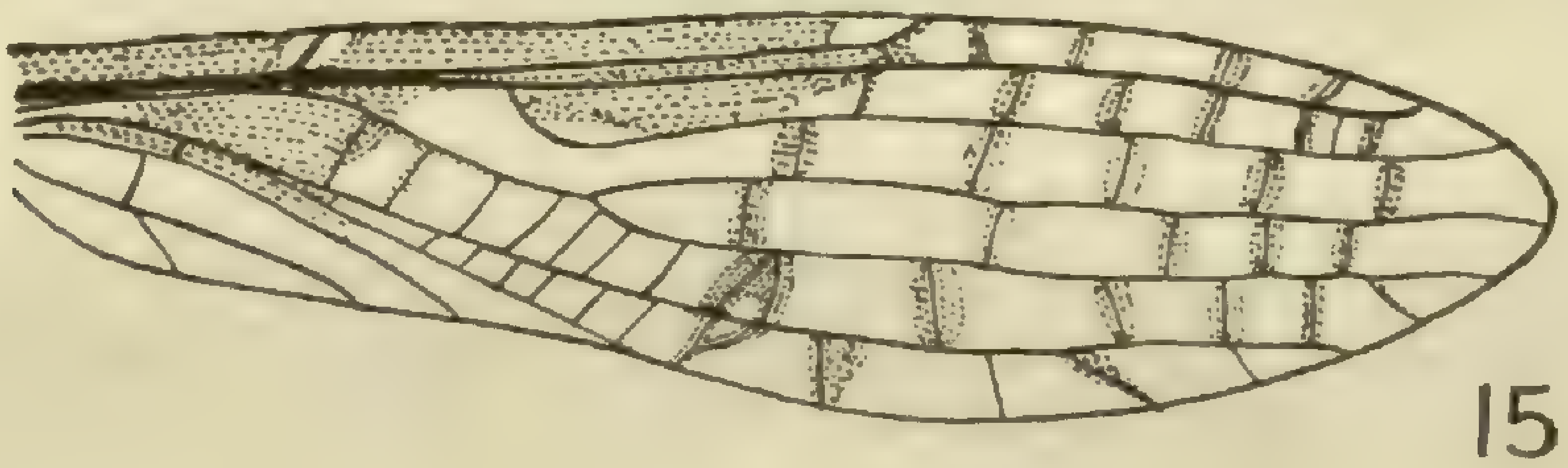
Zelandoperla maculata (Hare). (Figs. 15, 14*d*.)

Leptoperla maculata Hare, *Trans. N.Z. Inst.*, vol. 42, p. 29, 1910.

This species appears to be fairly closely allied to the preceding one, but may be distinguished from it by its smaller size (expanse 22 mm. to 27 mm.), longer antennae and cerci (the latter being as long as the abdomen), paler and more greyish coloration of forewings, and by the much narrower oval-shaped patches surrounding the distal veinlets (fig. 15). The pronotum is more rectangular in shape, and has the median longitudinal groove narrow for its whole length (fig. 14*d*).

Type in Mr. Hare's collection.

Locality.—Karori and Wainuiomata, near Wellington.



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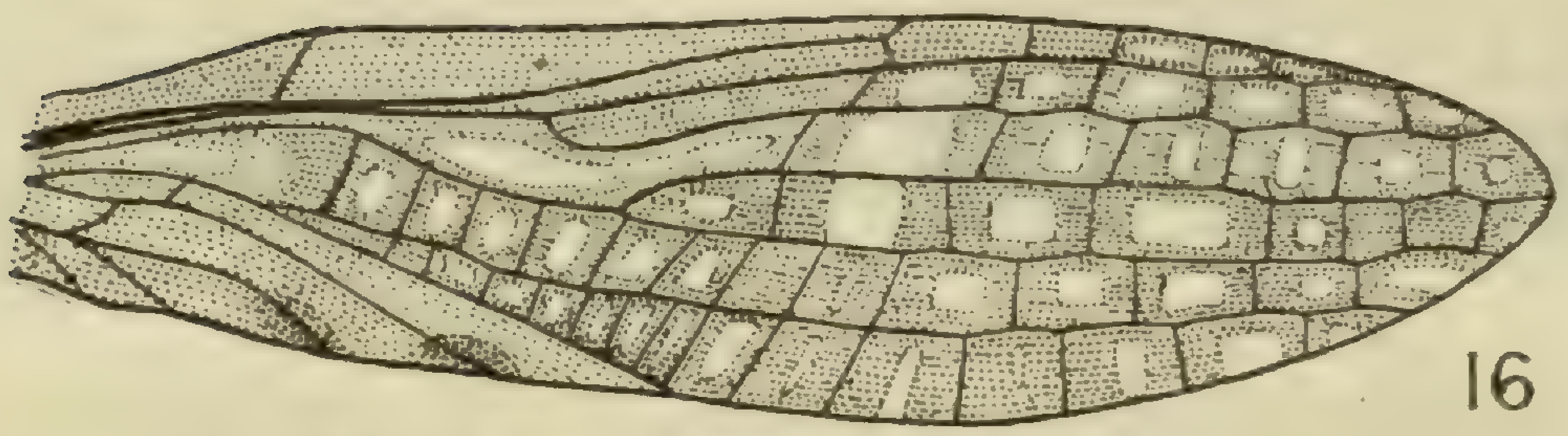

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Fig. 15.—Forewing of *Zelandoperla maculata* (Hare).
Fig. 16.—Forewing of *Zelandoperla fenestrata* n. g. et sp.

Zelandoperla fenestrata n. sp. (Figs. 16, 14 *b*, *c*.)

♀. Forewing, 13 mm.; hindwing, 11·5 mm.; expanse, 28 mm.

Superficially resembling *Z. decorata* n. sp., but can easily be distinguished from it as follows: Forelegs blackish, tibiae with a band of brown on second quarter; middle and hind legs brown, femora darkened along outer border. Ventral plate deeply divided medially, so as to form two projecting triangular lobes, hairy (fig. 14*c*). Wings not so darkly shaded as in *Z. decorata*, the ground-colour of the forewing being a medium fuscous brown, on which are numerous subhyaline patches situated in the cellules formed by the cross-veins; these patches are of varying shape, as shown in fig. 16, but mostly more or less rectangular. Hindwing pale semitransparent grey, tinged with brownish along basal two-thirds of costa and also basally along Cu. In this species also the basal joint of the antenna is

not so much enlarged as in *Z. decorata*, nor is the pronotum so definitely marked with grooves (fig. 14*b*).

Types.—Holotype female and series of paratypes in Cawthron Institute collection. (Holotype, Arthur's Pass, 16th January, 1920; R. J. T.).

Locality.—Arthur's Pass, January, 1920; taken by Mr. Howes and myself.

Some of the specimens show a distinct thickening of the pterostigma of the forewing, which tends to become unicolorous reddish-brown; in these cases the pterostigmatic veinlets become weak, and are not easy to see except with transmitted light.

Family NEMOURIDAE.

This family, so abundant in the Northern Hemisphere, has not yet been recorded from either New Zealand or Australia. A single genus, *Udamocercia* End., is known from Tierra del Fuego and southern Chile. The family is nevertheless found in both New Zealand and Australia, though individuals of the species are not at all commonly met with, as they are small and insignificant, and seldom fly. The larvae can be recognized at once by having no external gills, and apparently no cerci; though, as a matter of fact, cerci are present, consisting of a single segment only.

This is the only family present in New Zealand and Australia in which a transverse cord or anastomosis is developed on the wings. This transverse cord divides the wing into two nearly equal portions, the distal one containing only a set of main veins running subparallel to one another, and entirely devoid of cross-veins. The anal fan is usually less wide than in Leptoperlidae, and the third branch of 3A is very short.

Key to the Genera of Nemouridae found in New Zealand.

Wings rather broad, Sc not arching so as to meet or nearly to meet the costal margin. Cross-vein *m-cu* ending above exactly at the median fork, and in line with the basal piece of M_{1+2} above it, in the forewing .. .. *Notonemoura* n. g.

Wings narrower, Sc arching up so as to meet or nearly meet the costal margin. Cross-vein *m-cu* in forewing ending above on M_{3+4} at an angle to it; this latter vein much curved as it leaves the transverse cord .. .. *Spaniocerca* n. g.

Genus NOTONEMOURA n. g. (Fig. 17.)

Characters as in the key given above, to which may be added the following: Veinlets Sc_2 and R_{1a} present in pterostigma of forewing. Sc_2 only in that of hindwing. Intercubital space of forewing very wide; Cu_1 diverging strongly from M_{3+4} at its apex.

Genotype.—*Notonemoura latipennis* n. sp.

Notonemoura latipennis n. sp. (Fig. 17.)

♂. Forewing, 6 mm.; hindwing, 4·8 mm.; expanse, 13 mm.

Head testaceous; eyes, ocelli, and two spots in front of lateral ocelli blackish. Antennae 4 mm. long, dull greyish-brown, with slender whitish annuli at base of each segment.

Thorax: Pronotum rectangular, wider than long, testaceous, with a narrow anterior transverse blackish band, a well-marked median longitudinal groove, and on either side a crescentic dark mark and an outer spot, the former merging posteriorly into a broad dark posterior transverse

band. Meso- and meta-notum blackish, touched with brown in front. Legs brownish; hind femora with a testaceous patch on basal half, and hind tibiae slightly darkened distally.

Abdomen (shrivelled) blackish, changing to brown apically. An exceedingly long and pointed organ, apparently the copulatory hook, projects upwards from the end of the abdomen.

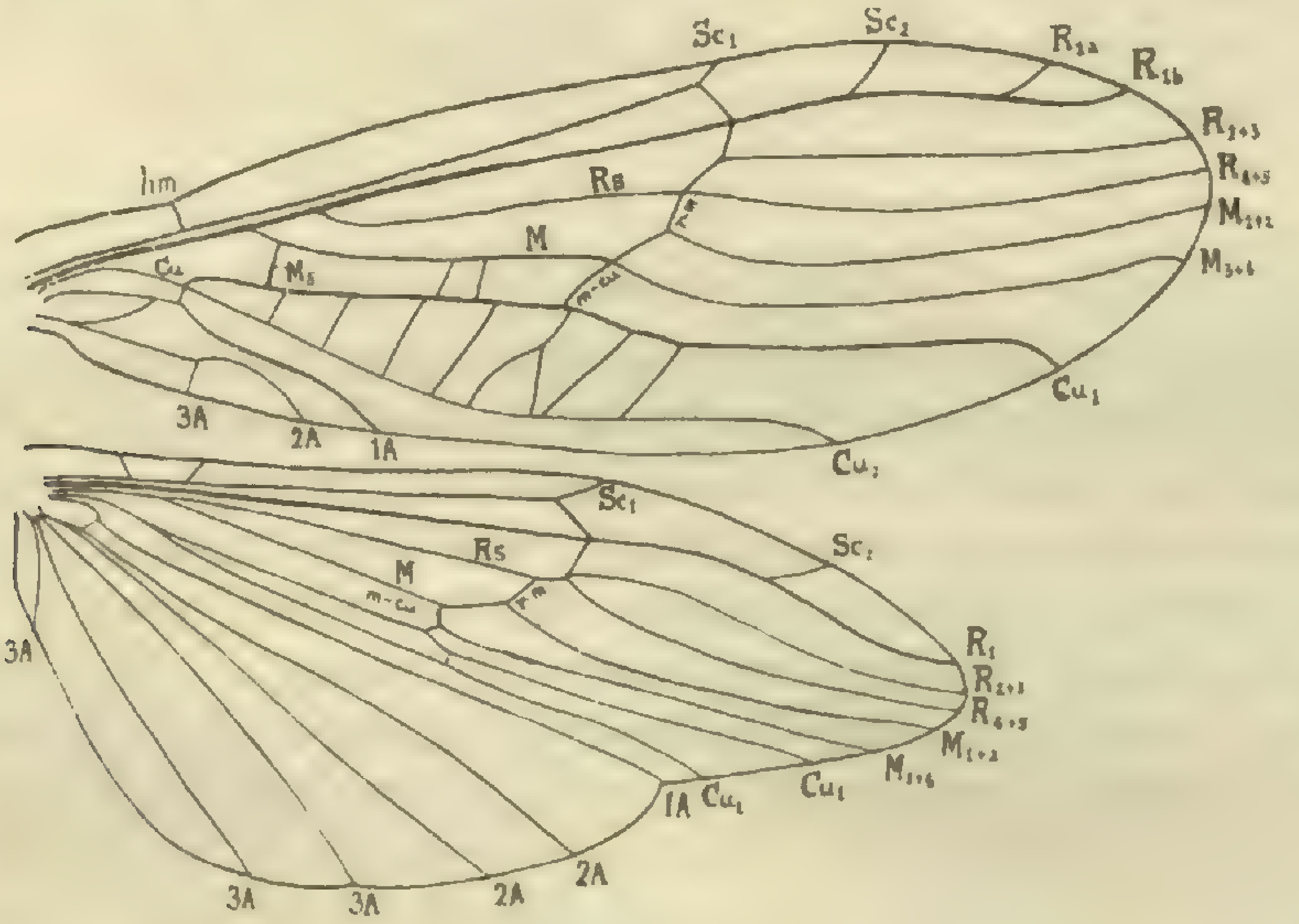

Fig. 17.—Wing-venation of *Notonemoura latipennis* n. g. et sp (For lettering see fig. 1, except *m-cu*, medio-cubital cross-vein, and *r-m*, radio-median cross-vein, forming portions of the transverse cord or anastomosis.)

Wings subhyaline, unicolorous; venation very pale testaceous, almost whitish.

Type.—Holotype male in Cawthron Institute collection, also a second specimen from Karori, both taken by myself.

Locality.—Arthur's Pass, 16th January, 1920 (R. J. T.); Karori, Wellington, 6th December, 1919 (R. J. T.).

Genus Spaniocerca n. g. (Fig. 18.)

Characters as given in the generic key, to which may be added the following: Pterostigma with only one veinlet, Sc_2, in both wings. Cross-vein *m-cu* very long in forewing, obliquely placed to rest of transverse cord. Anal fan rather narrow.

Genotype.—*Spaniocerca zelandica* n. sp.

Spaniocerca zelandica n. sp. (Fig. 18.)

♀. Forewing, 9 mm.; hindwing, 7·5 mm.; expanse, 19 mm.

Head, including antennae and eyes, dull greyish-black.

Thorax: Pronotum subrectangular, slightly wider in front than behind, dull greyish-black. Meso- and meta-notum jet black, the former with a large bright-brown patch posteriorly. Legs dull-brownish, the hind femora with a pale band in middle, the hind tibiae pale basally, darker distally.

Abdomen black, tenth tergite testaceous; ventral plate projecting beyond end of abdomen in the form of a narrow subtriangular tongue, pale testaceous in colour.

Wings: Forewing subhyaline, slightly infuscated, the veins rich brown and narrowly shaded with fuscous; at about two-thirds of the wing-length there is a faint indication of a pale transverse fascia. Hindwing very pale

fuscous, with brown veins not shaded. Pterostigma in both wings darkened, brownish in colour, except at extreme base for a short distance only, which is paler.

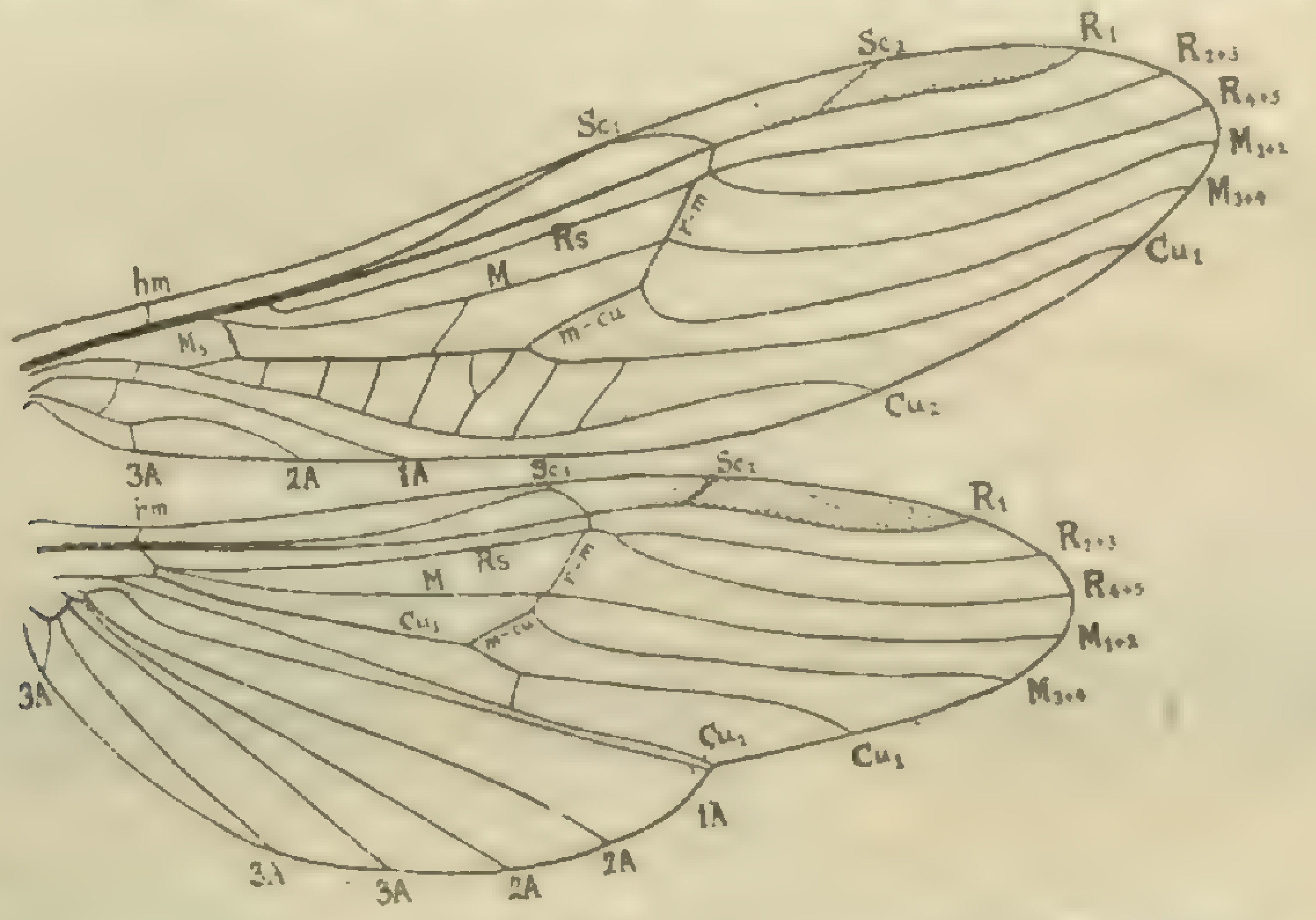

FIG. 18.—Wing-venation of *Spaniocerca zelandica* n. g. et sp. (For lettering see figs. 1 and 17.)

Type.—Holotype female in Cawthron Institute collection, also series of paratypes.

Locality.—Holotype taken at Nelson, 6th January, 1921, by Mr. A. Philpott. I have also taken specimens at Rotorua, Karori, and Dunedin.

There are also several other species of this genus to be found in New Zealand, but the working-out of them will require the collecting of much more material, and therefore they are left for a later paper.

In concluding this paper I desire to thank Mr. G. V. Hudson, F.E.S., F.N.Z.Inst., for giving me the opportunity of examining his type of *Leptoperla grandis*, and for giving me specimens of each of the four species of *Leptoperla* described by Hare.

ART. 19.—*Descriptions of New Species and Varieties of Lacewings (Order Neuroptera Planipennia) from New Zealand, belonging to the Families Berothidae and Hemerobiidae.*

By R. J. TILLYARD, M.A., Sc.D. (Cantab.), D.Sc. (Sydney), C.M.Z.S., F.L.S., F.E.S.; Entomologist and Chief of the Biological Department, Cawthron Institute, Nelson, N.Z.

[*Read before the Nelson Institute, 14th September, 1921; received by Editor, 16th September, 1921; issued separately, 17th February, 1923.*]

THE family Berothidae includes only five genera of lacewings, containing species which are very rare and widely scattered about the earth. Three of these genera—viz., *Spermophorella*, *Trichoma*, and *Stenobiella*—are Australian, but no representative of the family has so far been recorded from New Zealand. In this paper the first occurrence of the family for New Zealand is recorded, in the form of a new genus and species.

The family Hemerobiidae is world-wide, consisting of small lacewings whose larvae feed on aphids and psyllids. Two genera have been recorded

from New Zealand—viz., *Drepanacra* and *Micromus*—the former being purely Australasian, the latter world-wide. New Zealand possesses but one species of each of these genera, and both these species are also common in Australia. A new species of *Micromus* is added in this paper, together with a new species of the genus *Boriomyia*.

Family BEROTHIDAE.

In this family the forewing has the radial sector normal; the hindwing has the basal cross-vein connecting Rs with M placed in the normal transverse position, and Cu_1 runs for a very long distance close to and parallel with the posterior margin of the wing, sending to it numerous branched veinlets. This condition of Cu_1 is absolutely diagnostic for the family.

Genus PROTOBIELLA n. g.

Sc fused distally with R_1 in both wings. Forewing with the costal space very narrow at the base, but increasing to a considerable width in the basal third of the wing, thence becoming slightly narrower; Rs with five branches, and with three cross-veins connecting it with R_1; a basal cross-vein between R and M, just above the usual one connecting M with Cu_1; M and Cu both dichotomically branched; no definite gradate series, but three cross-veins forming a partial outer such series connect M_{1+2} and the two most posterior branches of Rs respectively; other cross-veins are—one between the two main branches of M, two between M_{3+4} and Cu_1, one between the two main branches of Cu, and the usual basal cross-veins between Cu_2, 1A, and 2A respectively, the latter one obliquely placed. Hindwing with the costal space very narrow all the way, and carrying only unbranched veinlets; Rs with five branches, and connected with R_1 by only two cross-veins; Cu_1 runs close above and subparallel to the posterior margin to well beyond half-way; the part of Cu_1 lying beyond the distal end of 1A does not send a series of veinlets arranged pectinately to the margin, such as descend from 1A itself, but gives off instead only four veinlets, which rebranch close to the margin; 1A is forked, each fork sending a pectinate series to the hind margin, the distal branch being much longer than the basal; an oblique cross-vein connects 1A with Cu_1, Cu_2 being entirely absent; a portion of a distal or outer gradate series is represented by three cross-veins connecting Cu_1, M_{3+4}, M_{1+2}, and the most posterior branch of Rs respectively. No scales present on hindwing in either sex.

Genotype.—*Protobiella zelandica* n. sp.

Habitat.—New Zealand only.

This genus resembles the Australian *Spermophorella* in its rounded wings, shape of costal space in both wings, fusion of Sc with R_1 distally in both wings, number of cross-veins connecting Rs with R_1, form of M and Cu, and lack of fusion between 1A and Cu_1 in hindwings. It differs from *Spermophorella* in the absence of a complete distal or outer gradate series of cross-veins in the forewing, and in the absence of the numerous veinlets arranged pectinately which descend from Cu_1 distally in the hindwing in that and other known genera of Berothidae. In this latter character *Protobiella* is clearly the most archaic genus of the family.

Spermophorella is peculiar in that the females possess a more or less extensive area of the hindwing bearing thickened, seed-like scales attached

to the veins. The female of *Protobiella* resembles the male in having no scales on the hindwing. Again, *Spermophorella* in Australia is known to have an especial liking for sandstone caves and hollows. The capture of *Protobiella* in a locality abounding in limestone caves may therefore indicate a similar cave-loving habit for the New Zealand genus.

These two genera differ widely from all other Berothidae in the shape of their wings, the other three genera having them either strongly falcate or excessively long and narrow.

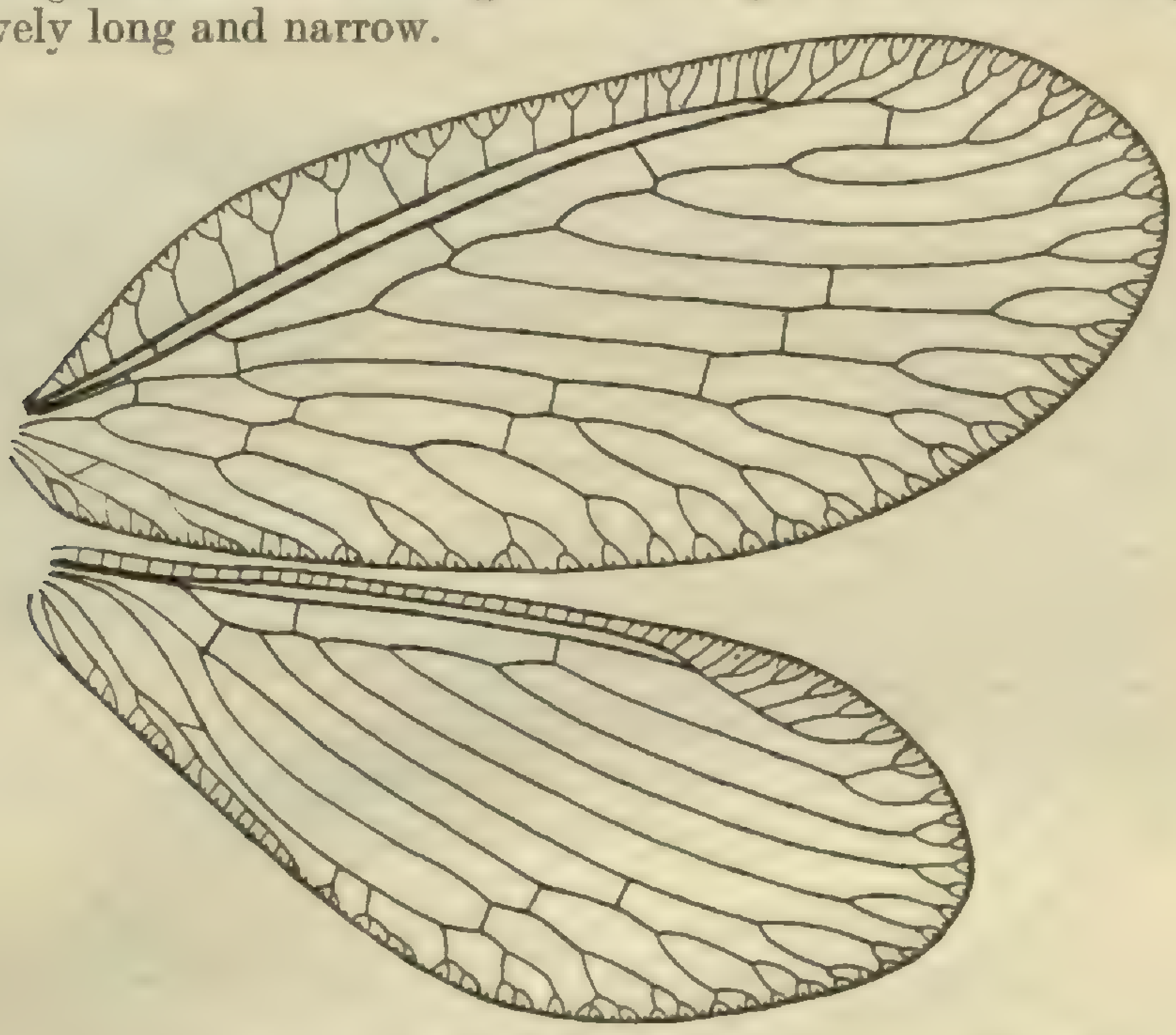

FIG. 1.—*Protobiella zelandica* n. g. et sp.: wing-venation. (For venational nomenclature see fig. 2.)

Protobiella zelandica n. sp.

♂. Forewing, 7 mm.

Head dark brown, with pale-testaceous spots; eyes grey-black; antennae (broken off) very dark brown, hairy, the basal joint enlarged, club-shaped.

Thorax dark brown, the sides of the pronotum yellowish. Legs testaceous touched with fuscous, and carrying numerous stiff, dark hairs.

Abdomen brown, hairy, and ending in large semitransparent yellowish appendages which appear squarish in lateral view and are turned under the end of the abdomen so as to project forwards beneath it.

Wings: Forewing very slightly clouded and lightly irrorated all over with pale fuscous; veins speckled alternately with fuscous and pale testaceous. Each cross-vein is prominently marked out by a small fuscous cloud enclosing it, and there are five fuscous patches situated along the distal half of the costal margin. Hindwing subhyaline, the veins unicolorous, fuscous; the two cross-veins between R_1 and Rs slightly clouded, and one or two fuscous patches along costa towards apex.

♀. Similar to male, but larger (forewing 8·5 mm.), and somewhat more heavily spotted on forewing. Abdomen ending in two short processes projecting downwards and slightly forwards from the down-curved apex.

Locality.—Terakohe, near Takaka, Golden Bay, N.Z.; a single male specimen, taken by myself on the evening of 6th February, 1921. Waitati, 13th December, 1916; a single female.

Type.—Holotype male and allotype female in Cawthron Institute collection.

Family HEMEROBIIDAE.

In this family the stem of the radial sector is suppressed, in the fore-wing only, so that R_1 appears to give off a series of two or more separate radial sectors; in the hindwing the basal cross-vein connecting Rs with M is placed longitudinally, and is curved sigmoidally. Cu_2 may or may not be present in hindwing, but Cu_1 never runs close to and parallel with the

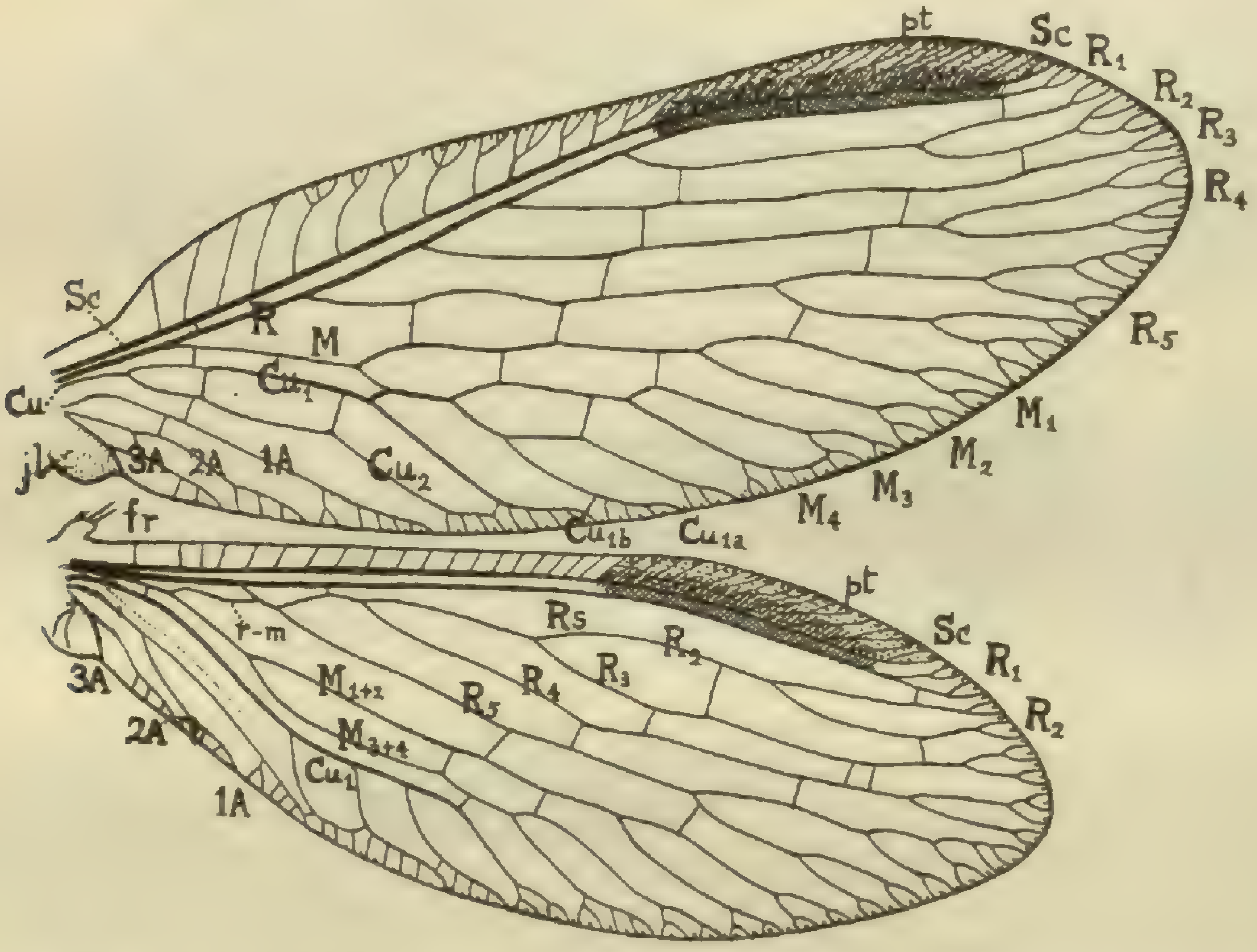

FIG. 2.—*Micromus tasmaniae* (Walker) var. *manapouriensis* nov.: venational scheme, with Comstock-Needham notation. 1A, 2A, 3A, the three anal veins; Cu, cubitus; Cu_1, first branch of cubitus, dividing in forewing into Cu_{1a} and Cu_{1b}; Cu_2, second branch of cubitus; *fr*, frenulum; *jl*, jugal lobe; M, media; M_1, M_2, M_3, M_4, its four branches; *pt*, pterostigma; R, radius; R_1, main stem of radius; Rs, radial sector; R_2, R_3, R_4, R_5, its four branches (all of which appear, in the forewing, to arise separately from R itself); *r-m*, basal longitudinal cross-vein, in hindwing, joining R to M, and sigmoidally curved; Sc, subcosta. In the figure the pterostigma is heavily shaded; in the insect itself this area is opaque, testaceous in colour, with the course of Sc through it only very faintly indicated.

posterior margin, as it does in the Berothidae. The frenulum is usually well developed in the hindwing. This type of venation is well illustrated by the genus *Micromus*, which is shown in fig. 2 as a guide to the correct interpretation of the veins in the other figures.

The three genera at present found in New Zealand may be separated by the following key:—

1.	Forewing with a broad costal space, having at its base a recurrent humeral veinlet	2
	Forewing with a narrow costal space, without recurrent humeral veinlet; four to six radial sectors ..	*Micromus.*
2.	Forewing falcate, with six or more radial sectors ..	*Drepanacra.*
	Forewing well rounded, with only three radial sectors ..	*Boriomyia.*

Boriomyia maorica n. sp.

Forewing, 9·2 mm. (Specimen apparently a female, but abdomen very shrivelled.)

Head, thorax, and *abdomen* blackish ; eyes dark brown ; antennae broken off ; a touch of dark brown on notum and some brownish hairs towards end of abdomen. Abdomen curved downwards apically, broadening dorso-ventrally, and ending in a sharp hook-like projection, which bends forwards and upwards beneath the last three segments.

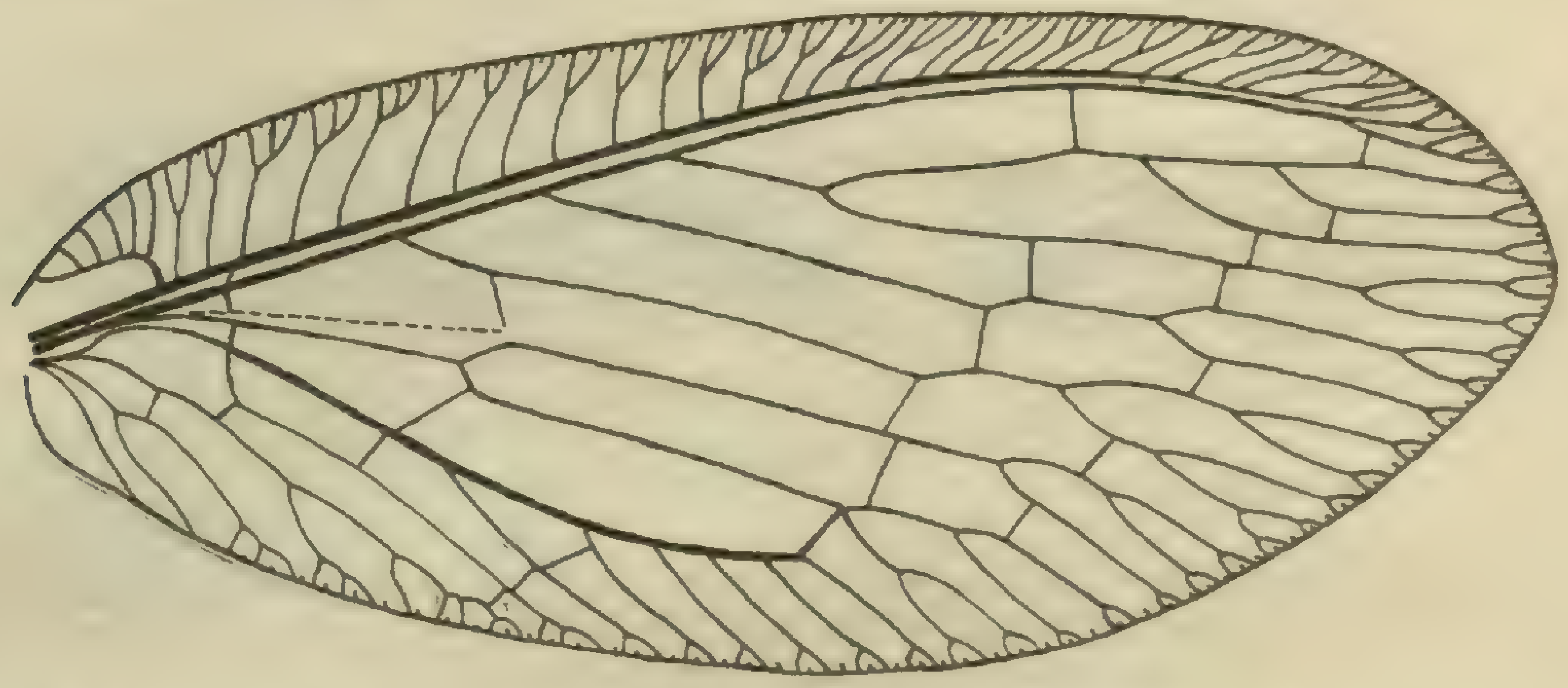

FIG. 3.—*Boriomyia maorica* n. sp. : venation of forewing. (For venational nomenclature see fig. 2.)

Wings : Forewing iridescent subhyaline, very lightly irrorated all over with pale-fuscous spots and blotches ; veins speckled alternately with dark fuscous and pale testaceous. More prominent markings are as follows : a dark-fuscous spot on subhumeral cross-vein, three similar spots on Cu_1 (one at the origin of the two cross-veins, one at the secondary cubital fork, and one at origin of the most basal branch of Cu_{1a}, at the point where a cross-vein descends on to Cu_{1b}), another on fork of M_{3+4} ; the gradate series (of which there are two in the forewings of *Boriomyia*) are also outlined in dark fuscous. Hindwing faintly clouded all over with pale fuscous ; the veins unicolorous, Sc and the costal veinlets being brownish, all the rest dark fuscous ; pterostigmatic area very slightly darkened.

Locality.—Dunedin, N.Z. One specimen, apparently a female, taken at light by myself in Mr. W. G. Howes's residence in George Street, in February, 1920. About a week later Mr. Howes captured a second specimen of the same species.

Type.—Holotype female (?) in Cawthron Institute collection.

Micromus bifasciatus n. sp.

♀. Forewing, 7 mm.

Head, thorax, and *abdomen* (shrivelled) bright medium brown ; antennae same colour, 3 mm. long ; epicranium with two patches of darker brown ; eyes dark brown. Legs testaceous.

Wings hyaline, with pale-testaceous venation. Forewing with two very strongly marked oblique bands of a dark fuscous-brown colour ; one of these runs from Cu_1 up to R_2, covering the whole of the inner gradate series, and has a slight extension distad along R_3 ; the other similarly covers the outer gradate series from Cu_1 up to the lower branch of R_2, ending up close to apex. The inner band is practically complete ; the

outer band is broken between Cu_1 and M_{3+4}, and again between M_{1+2} and R_5, and is generally of a more irregular shape than the inner band. There is also an elongated patch of fuscous-brown along and below R_1 covering the origins of R_3, R_4, and R_5; the lower half of the pterostigma is also fuscous-brown, and a shorter dark patch covers the main stems of M and Cu_1, and more or less joins up with the lower end of the inner oblique band already described. There is also a series of small patches along the margin of the wing, those on the costa very small, those on the posterior

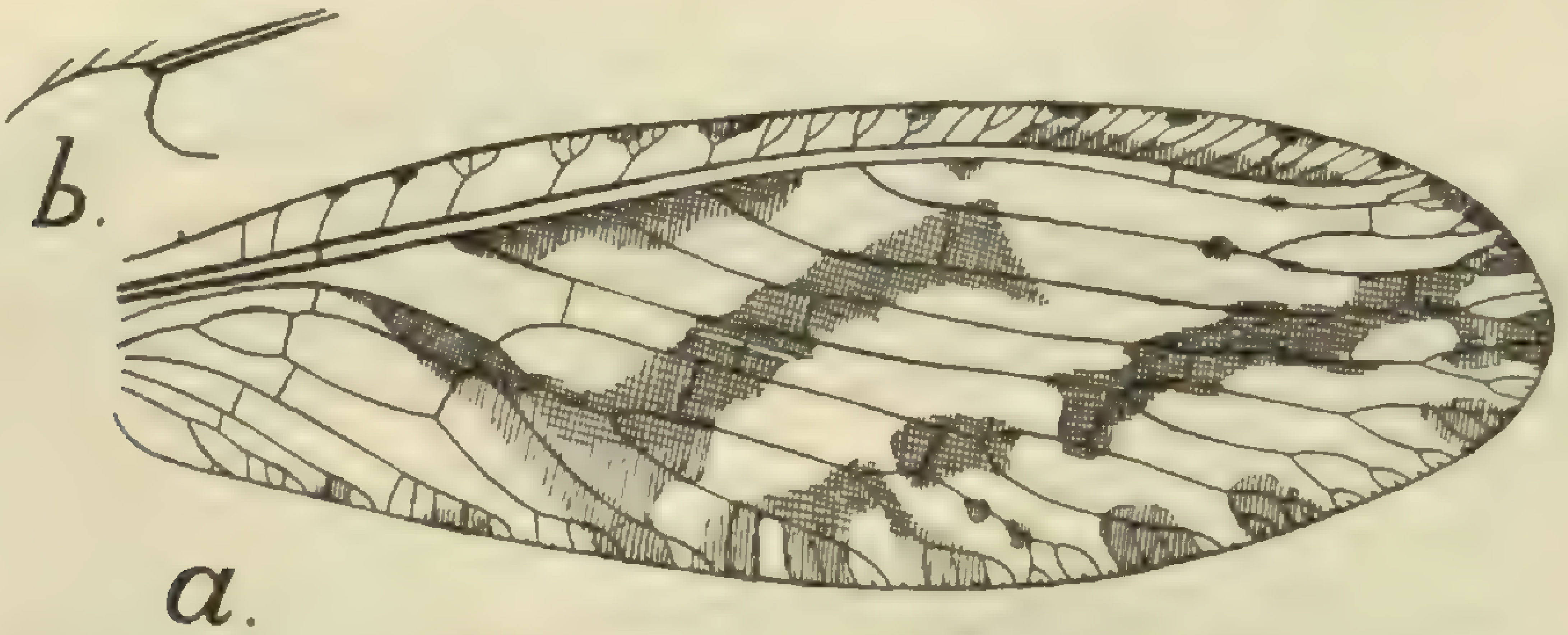

FIG. 4.—*Micromus bifasciatus* n. sp.: *a*, venation and colour-pattern of forewing; *b*, fenulum of hindwing, enlarged. (For venational nomenclature see fig. 2.)

margin from end of Cu_1 to apex considerably larger. Hindwing hyaline, pterostigma testaceous; frenulum well developed, with two strong bristles very close together (fig. 4, *b*). Male similar to female, but less darkly banded. Appendages large, somewhat spatulate, turned vertically downwards.

Locality.—West Plains and Tisbury, near Invercargill, N.Z. Taken by Mr. A. Philpott, F.E.S., in September, 1905, and again in March, 1920. One female and two males.

Types.—Holotype female (West Plains, 29th September, 1905, A. Philpott) and allotype male (Tisbury, 1st March, 1920, A. Philpott) in Cawthron Institute collection. Also a single paratype male.

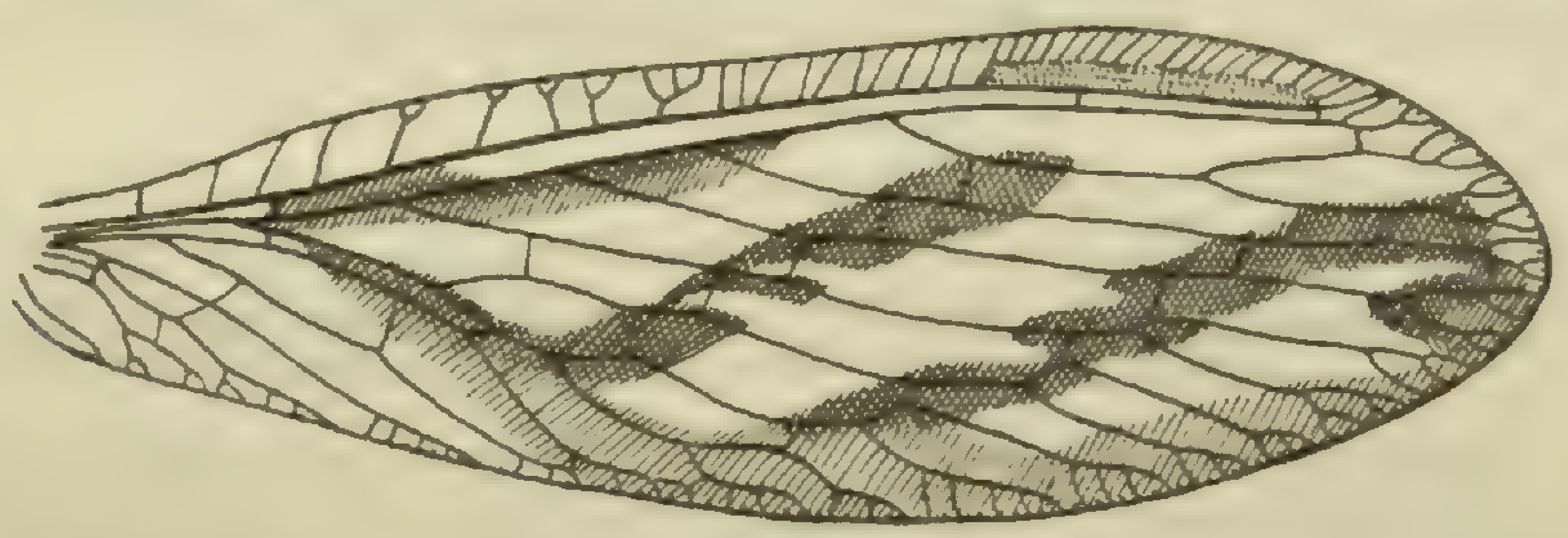

FIG. 5.—*Micromus bifasciatus* n. sp. var. *amabilis* nov.: venation and colour-pattern of forewing. (For venational nomenclature see fig. 2.)

Variety *amabilis* nov.—A single male taken on rimu at Silverstream, near Wellington, by Mr. H. Hamilton, is a much more beautiful insect than the type series. Both fore and hind wings are beautifully iridescent, and all the veins are rose-pink, except Sc, which is brown. The two oblique bands are much more regular and complete than in the type form, and are of a rich chocolate-brown colour; the margins of both wings are almost entirely suffused with brown. Abdomen rose-pink above, yellowish-brown beneath.

In the colour of the veins this variety parallels the beautiful variety *rubrinervis* Till. of *Drepanacra binocula* (Newm.), which Mr. G. H. Hardy took in Tasmania.

Variety *imperfectus* nov. — A single specimen from Gisborne, N.Z. (undated), has the inner oblique band absent, replaced by the very faintest yellowish-brown tinge, while the outer oblique band is exceedingly narrow, of a bright umber-brown colour; Sc and R are brown in both wings.

Both the above varieties are in the Cawthron Institute collection.

Micromus tasmaniae Walker. (Fig. 2.)

Micromus froggatti Banks, 1909.

This species is very common throughout Australia, Tasmania, and New Zealand. It is very variable in size, the expanse of the wings measuring from 11 mm. to 19 mm. It also varies considerably in the intensity of the speckling of the forewings. The normal markings are a somewhat opaque testaceous pterostigma on both wings, and, on the forewing only, a series of fuscous dots around the whole wing-margin, irregular speckling of the veins with fuscous, slight clouding of the gradate series, and a usually very conspicuous small blotch of dark fuscous covering the fork of M, and extending below it to Cu_1.

Variety *manapouriensis* nov. — Mr. Philpott captured, on the 13th February, 1920, two fine specimens in which the normal spotting of the veins of the forewing is almost completely absent, being replaced by a much less conspicuous pattern of pale-brownish veins lightly speckled with a darker shade of brown; also, the whole of both wings is suffused with a very pale yellowish-brown tinge, which is normally quite absent in this species. The specimens are in the Cawthron Institute collection.

Variety *nigroscriptus* nov.—A single specimen was taken by Mr. Philpott in Nelson on the 29th December, 1920, which shows a very striking and unusual pattern on the wings. At first sight it would appear to be a new species; but I am unable to differentiate it from *M. tasmaniae* by any other characters except the wing-pattern, and so I prefer to name it as a variety only. In the forewing there is a curved black stripe occupying the narrow space between M and Cu_1 basally, and continued downwards along Cu_1; the inner gradate series is conspicuously marked in black, and a subtriangular area at the apex, covering all the veins from the end of the pterostigma to the apex itself, and extending narrowly downwards along the first half of the outer gradate series, is also marked in black. In the hindwing the corresponding portions of the wing have the veins lightly marked in black, so that when the wings are folded in the position of rest the darkened areas reinforce one another. This specimen is in the Cawthron Institute collection.

Drepanacra binocula (Newman).

Drepanepteryx binocula Newman, 1838.

The number of species of *Drepanacra* described from Australia and New Zealand is quite considerable, and I myself have added two species from Australia and one from Norfolk Island, together with several varieties. There are also in my collection a number of other forms which once appeared to me to be good species. However, in the spring of 1917 I reared from a large brood of larvae on a single wattle-tree in my garden at Hornsby, N.S.W., more than two hundred specimens, undoubtedly all belonging to a single

species, which showed an enormous variation in size, venation, and colour-pattern, and included not only all the supposed species already described from Australia, but also all the known New Zealand forms, together with a striking new variety which had previously been sent me from New Zealand but had remained undescribed. Of this series the commonest varieties by far were *humilis* McL. (almost unicolorous brown or fawn) and *instabilis* McL. (with irregular broken fasciae and irrorations). The rarest of all, totalling only three specimens out of the whole lot, was the original type described by Newman as *Drepanepteryx binocula* in 1838, which had remained undiscovered ever since. This form has a conspicuous circular eye-spot (black centre and pale outer ring) covering the fork of Cu_1 and extending down to the fork of 1A, in the forewing.

It follows that the specific name of the single Australian and New Zealand species now becomes *Drepanacra binocula* (Newman), while McLachlan's species,* together with those subsequently described by Hare† and myself,‡ must sink to the status of varieties. Of the two New Zealand species described by Hare, *D. maori* appears to me to be barely distinct from var. *instabilis* McL., while *D. humilior* is only a small form of var. *humilis* McL., such as occurs on the Dun Mountain, Nelson, in company with larger and more typical forms. Such dwarf forms can easily be obtained by restricting the quantity of food given to the larva in captivity.

The following new varieties of this exceedingly variable species are here described for the first time :—

Variety *excisa* nov.—The forewing is of the *humilis* type (brown, with very light irrorations), or fuscous, with heavier irrorations, tending towards the *instabilis* type, but is remarkable in having a large irregular pale patch placed so as to cover the upper portion of the space between the distal and middle gradate series, and extending up on to the costa. This gives the insect, when at rest, the appearance of a small dead leaf with a big piece cut out of it, and ought to be very effective as a protection against birds and other enemies. Taken at Opoho Hill, Dunedin, on the 31st December, 1919, by myself (this specimen is dark fuscous, and has the anal area of forewing very pale); at Nelson, on the 8th December, 1921, by Mr. A. Philpott (forewing dark fuscous); and at Forest Hill, Invercargill, on the 29th December, 1915, by Mr. A. Philpott (forewing nearly uniform brown, with anal area only slightly paler).

Variety *divisa* nov.—The forewing is divided by an almost straight line, running from base to apex, into a very pale upper area and a brownish-fuscous lower area, the latter having the gradate series slightly clouded. This is evidently a further specialization from var. *longitudinalis* Till. A single specimen only, of rather small size, taken at Tisbury, near Invercargill, by Mr. A. Philpott, on the 9th February, 1913.

Variety *bilineata* nov.—Of same type as *divisa*, but the dividing-line is double, being pale above and dark below. The upper area, instead of being pale, is brown and irrorated; the lower half, beneath the dark-fuscous lower dividing-line, is also brown, but uniformly so, as in typical *humilis*. A single specimen, taken by myself at Queenstown, 17th December, 1919. A fine specimen, combining typical *bilineata* pattern of forewing with

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* *Journ. Entom.*, vol. 2, pp. 111–16, 1863.

† *Trans. N.Z. Inst.*, vol. 42, pp. 29–33, 1909.

‡ *Proc. Linn. Soc. N.S.W.*, vol. 41, pt. 2, pp. 301, 302, 1916; also the same, vol. 42, pt. 3, p. 532, 1917.

the prominent eye-spot of *binocula* itself, was taken at Nelson on the 8th December, 1920, by Mr. Philpott.

Variety *suboculata* nov.—Generally similar to the type form of the species (*binocula* Newm.), but the eye-spot is absent; instead of it there is a dark spot about half-way along the posterior margin, somewhat semicircular in shape, dark fuscous with a paler centre; this spot is generally rather irregularly formed, but the general effect is to suggest the upper half of an eye-spot appearing above the wing-margin. In both this variety and typical *binocula* the ground-colour of the forewing may be either greyish or brown, and these is generally considerable irroration and subfasciation, as in *instabilis* McL. Nelson, 8th December, 1920 (forewing grey); West Plains, Invercargill (forewing brown); also Hornsby, N.S.W. (several, forewings grey).

The known varieties of this remarkably variable species may now be listed as follows:—

A. Oculate or semi-oculate forms: *binocula* Newm. (type), *suboculata* var. nov.

B. Self-coloured or only slightly irrorated forms: *humilis* McL., *humilior* Hare, *hardyi* Till., *tasmanica* Till.

C. Strongly irrorated forms, with more or less irregular fasciation or subfasciation: *instabilis* McL., *maori* Hare, *froggatti* Till., *rubrinervis* Till., *pallida* Till., *insularis* Till. The first three and the last of these are scarcely sufficiently distinct, the variation in size, shape of wing, and venation being particularly marked amongst these forms.

D. Longitudinally lined forms: *longitudinalis* Till., *divisa* var. nov., *bilineata* var. nov.

E. Geographical race, with wings rather broad and short, not strongly falcate, size small, markings various: *norfolkensis* Till. and var. *lineata* Till. This form occurs only on Norfolk Island, but I am doubtful whether it is sufficiently distinct to merit the name which I gave it, as many New Zealand specimens approach it very closely in size and shape. In the specimens studied, varieties of the *humilis*, *instabilis*, and *longitudinalis* types were represented. Thus it would appear that the species is just as variable on Norfolk Island as elsewhere.

In the above descriptions all the remarks apply to the forewing. The hindwing varies little, but is more heavily clouded around the margin in those varieties in which the forewing is most heavily coloured.

In conclusion, it would appear evident enough that if attention were paid by collectors in New Zealand to these interesting little insects, especially in the spring and autumn, and by carefully sweeping any native trees or bush which appears to be affected with psyllids, scale insects, &c., the present scanty record for New Zealand may be considerably enlarged, as has been the case quite recently in Australia when similar methods have been adopted. The close relationship existing between the Planipennia of New Zealand and Australia is already clearly proved, and we may anticipate that, before very long, new forms closely related to such Australian genera as *Notiobiella*, *Carobius*, and *Psychobiella* will be discovered, especially if native pine-trees, such as kauri, rimu, and totara, are carefully searched for these insects.

Art. 20.—*Descriptions of Two New Species of May-flies (Order Plectoptera) from New Zealand.*

By R. J. Tillyard, M.A., Sc.D. (Cantab.), D.Sc. (Sydney), C.M.Z.S., F.L.S., F.E.S.; Entomologist and Chief of the Biological Department, Cawthron Institute, Nelson, N.Z.

[*Read before the Nelson Institute, 19th October, 1921; received by Editor, 26th October, 1921; issued separately, 17th February, 1923.*]

Plate 19.

The may-flies, which belong to a very distinct and primitive order, called by some authors the Plectoptera, by others the Ephemeroptera, are well represented in New Zealand, though the introduction of the various species of trout has greatly diminished the abundance of the larger species, and one or two of the finest of them appear to be on the verge of extinction. Thirteen species, belonging to six genera and three families, have already been described, while a considerable number of the smaller species have not yet been worked out. In the present paper two fine new species are added, one belonging to the Siphluridae, the other to the Ephemeridae.

The opportunity is taken in this paper to offer an entirely new venational notation for the order. This is given in fig. 1. This interpretation of the venational scheme was first worked out from a study of the tracheation of the larval wings of New Zealand species of Siphluridae, and was later on found to agree exactly with the venational scheme of the very primitive Plectoptera described from the Upper Permian of Kansas by Sellards. A paper embodying these results is in course of preparation, and will be published elsewhere.

The plate showing the male imago and female subimago of *Ichthybotus bicolor* n. sp. has been prepared from a photograph taken by Mr. W. C. Davies, Curator of the Cawthron Institute, to whom I here desire to express my thanks. The text-figures have all been drawn with the Abbé camera lucida.

Family SIPHLURIDAE.

Genus Ameletus Eaton.

Ameletus flavitinctus n. sp.

♀. *Imago:* Total length, 18 mm.; forewing, 19·5 mm.; hindwing, 7 mm.; expanse, 41 mm.

Head (somewhat shrivelled) small, dull medium brown; eyes dull-blackish.

Thorax: Pro- and meso-thorax rich umber-brown above; metathorax dark chocolate-brown above; sides dull brown shading to pale brown beneath; mesonotum with two blackish marks placed close up on either side of the median suture posteriorly. Legs short, pale brown, the femora with a broad black median band and a narrower black band at apex; tibiae marked with black apically; tarsi blackish, except for the bases of the first three segments, which are pale-brownish. Fig. 2, *g*, shows the tarsus of the hind leg, for comparison with that of *Ameletus ornatus* (fig. 2, *h*), an insect of somewhat smaller size but with much larger legs.

Abdomen narrow subcylindrical, tapering posteriorly. Segments 1–6 dark brown, heavily marked with dull-blackish in the form of a transverse basal band, from which project two elongated longitudinal marks, one on either side of the median line, and reaching to within a short distance of the apex of each segment; 7–8 paler brown, with similar blackish basal band, but with shorter longitudinal projecting marks, reaching only about half-way along each segment; 9 pale brown, with very narrow blackish basal band and slender longitudinal projecting marks; 10 pale brown, with narrow blackish basal band and no projecting marks. Ventral valve cleft in middle, its margin forming two rounded lobes (fig. 2, *f*); those of the other New Zealand species are shown for comparison in fig. 2, *d*, *e*. Cerci (partially shrivelled) somewhat longer than abdomen, brown, with darker segmental rings. Appendix dorsalis much reduced, only 3 mm. long, much shrivelled, with numerous minute obsolescent segments.

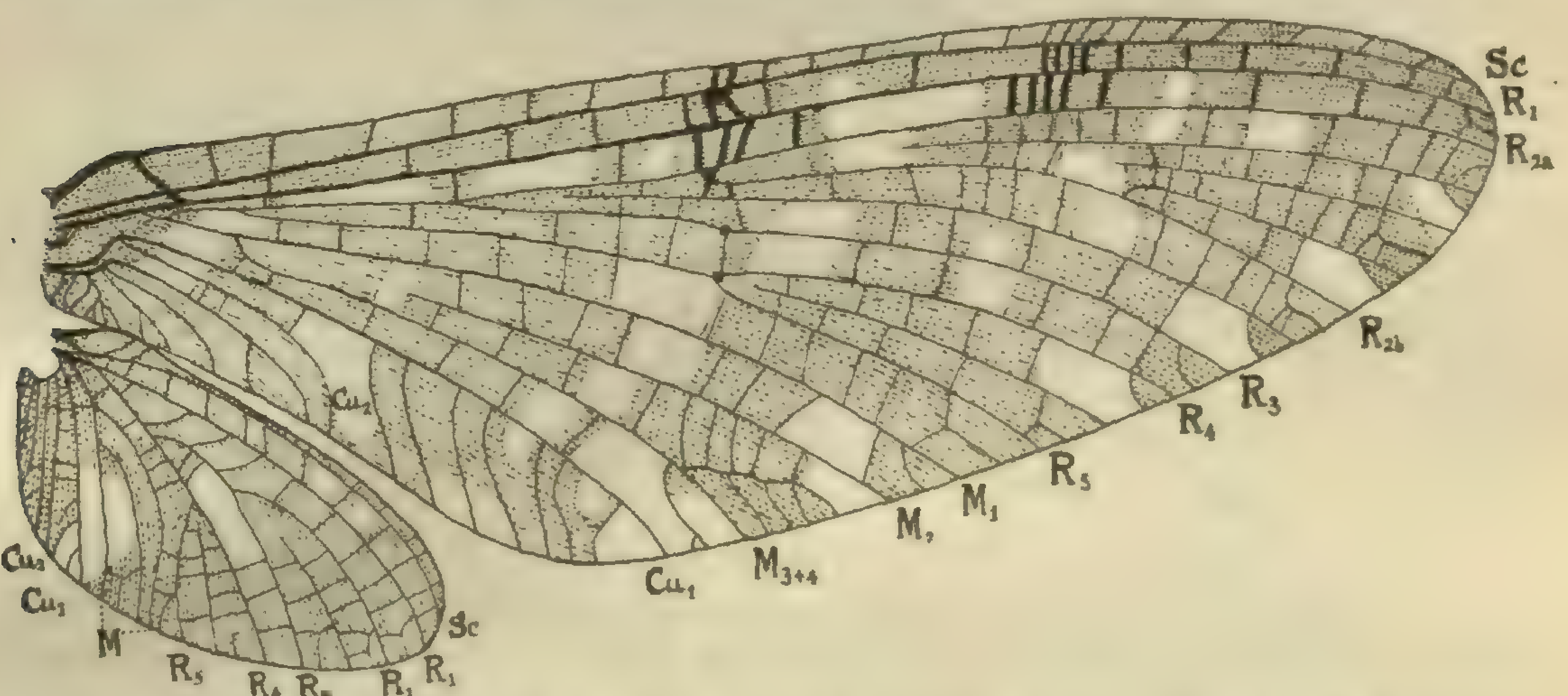


FIG. 1.—*Ameletus flavitinctus* n. sp.: female imago, wings. × 5·4. The shaded portions of the wing represent the parts coloured pale transparent yellow, the unshaded portions those which are hyaline. Cu, cubitus; M, media; R, radius; Sc, subcosta. Note the positions of the two groups of thickened cross-veins and of the bullae in the forewing.

Wings brilliant, most of the membrane a pale transparent yellowish, but with certain areas left absolutely hyaline, as shown in fig. 1. It will be seen that these areas are chiefly those formed where the very irregularly placed cross-veins lie farthest apart. Veins blackish. Forewing with two groups of thickened black cross-veins between Sc, R_1, and R_2, one set being about half-way along the wing, the other below the proximal part of the pterostigma. There is a series of five definite spots or bullae on the forewing, on Sc, R_1, R_2, R_3, and R_4 respectively, the first three being large and situated in the midst of the first set of thickened cross-veins already mentioned, while the last two are smaller and situated below them. In shape the forewing is similar to that of *Ameletus ornatus* Eaton. Hindwing with the humeral angle as shown in fig. 2, *c*; the same portion of the hindwings of *A. perscitus* Eaton and *A. ornatus* Eaton are shown for comparison in fig. 2, *a*, *b*.

♀. *Subimago*: The specimen described above was captured in the subimaginal stage, but had changed into the imaginal stage before it was killed. The subimaginal stage has opaque wings, remarkably variegated in the bold manner shown in the subimago of *Atalophlebia versicolor* Eaton.

Male unknown.

Type.—Holotype female imago in Cawthron Institute collection.

Locality.—Stream above high waterfall at Wahi, near Tokaanu, southern end of Lake Taupo, 26th November, 1919 (R. J. T.).

This fine species is easily distinguished from *A. perscitus* by its slenderer build, its narrower wings with much less dense venation, and by the yellow colouring of the wings being paler and not covering the whole wing. It is more closely allied to *A. ornatus*, which it resembles closely in shape and venation, but can be at once distinguished from it by the colour-pattern of the wings both in the imago and subimago, by the presence of the two groups of thickened cross-veins on the forewing (*A. ornatus* ♀ has only the single group around the bullae), by the shape of the humeral angle of the hindwing, by the shortness and slenderness of the legs, and finally by the very differently shaped ventral valve. It should

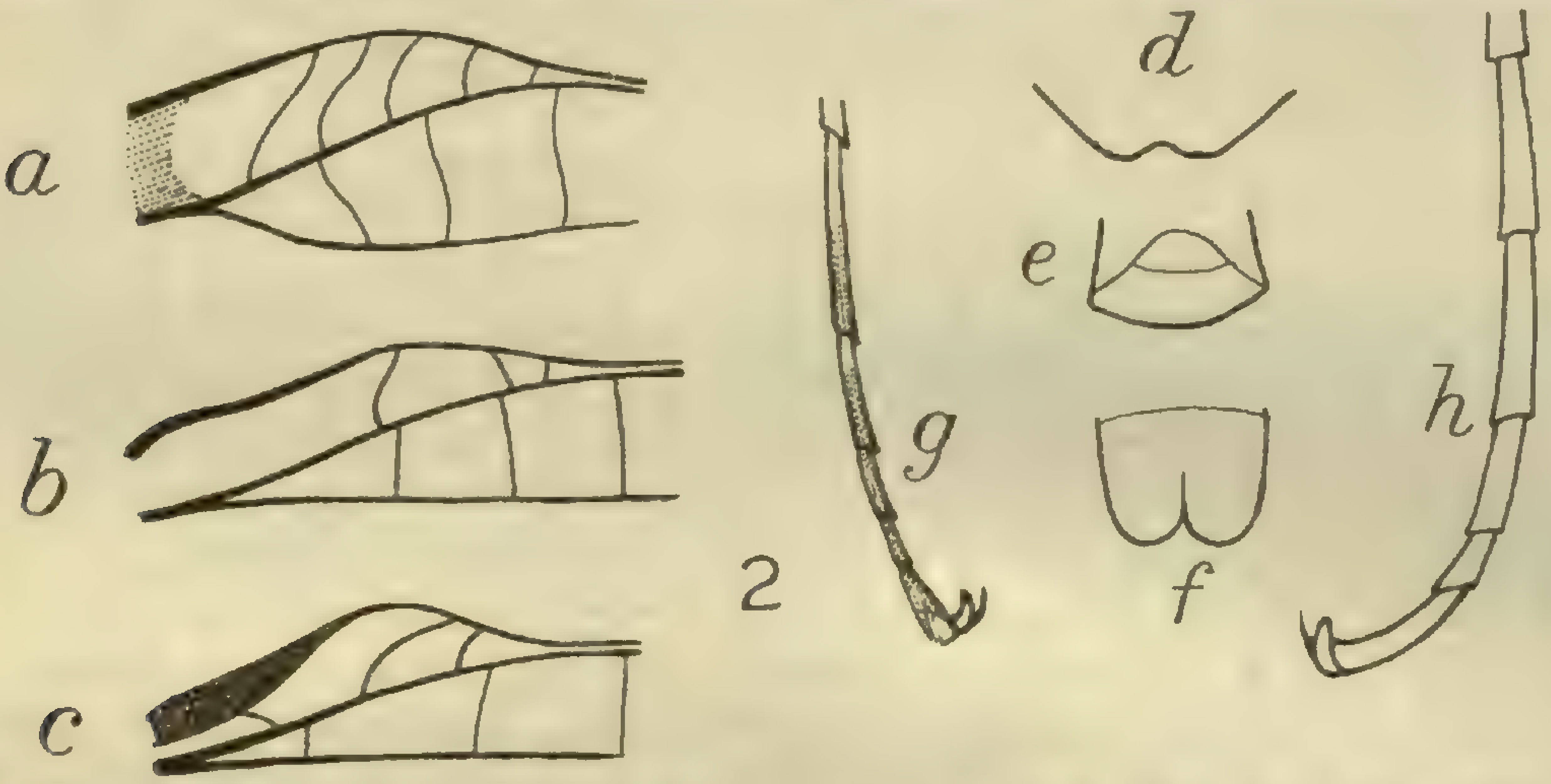


Fig. 2.—Details of the morphology of the female imago in the three New Zealand species of *Ameletus*: *a*, *A. perscitus* Eaton, humeral angle of hindwing; *b*, the same in *A. ornatus* Eaton; *c*, the same in *A. flavitinctus* n. sp.; *d*, *A. perscitus* Eaton, ventral valve; *e*, the same in *A. ornatus* Eaton; *f*, the same in *A. flavitinctus* n. sp.; *g*, *A. flavitinctus* n. sp., hind tarsus; *h*, *A. ornatus* Eaton, hind tarsus. All figures × 14.

be noted, however, that some female imagines of *A. ornatus* show slight yellow colouring along the costal margin of the forewing, this tint being distinctly more greenish-yellow than lemon-yellow, and giving the insect a very peculiar appearance.

It seems advisable here to point out that *A. perscitus* Eaton differs very greatly from both *A. ornatus* Eaton and *A. flavitinctus* n. sp. in the shape of its wings, the density and regularity of their cross-venation, and in the remarkable structure of its large-headed larva. These characters, taken together, suggest that it is not really congeneric with them. Further than this, a study of the three New Zealand species shows that they differ considerably from the genotype, *A. subnotatus* Eaton, from North America, and it appears probable that they may have to be placed in two new genera.

Family EPHEMERIDAE.

Genus Ichthybotus Eaton.

Ichthybotus bicolor n. sp. (Plate 19, and text-figs. 3–5.)

♂. *Imago:* Total length, 19 mm.; forewing, 16 mm.; hindwing, 6 mm.; expanse, 33 mm.

Head deep chocolate-brown; eyes blackish.

Thorax deep chocolate-brown; legs the same colour, except coxae and bases of the femora, which are paler. Foreleg 10·5 mm. long.

Ichthybotus bicolor n. sp. × 2. Upper figure, male imago; lower figure, female subimago.

Abdomen deep chocolate-brown, faintly mottled with somewhat paler brown; in shape slender subcylindrical, slightly narrowed at 5–7, broadening again at 8–9; 9 much wider than 10, broader apically than basally. Cerci 23 mm. long, dark chocolate-brown, strongly formed, slightly hairy, the segments cylindrical with narrow black basal rings. Appendix dorsalis vestigial, 1 mm. long, with few segments.

Appendages of the same type as in *I. hudsoni* McL., but with the following differences: Forceps basis slightly shorter and cut off obliquely on either side of its posterior margin, which, between the bases of the forceps, is cut straight off, not double-curved as in *I. hudsoni* McL.; pale brown in colour, with a large shield-shaped central area of dark brown, with two black dots on it. Forceps with segment 1 broad, as in *I. hudsoni* McL., but more sharply angulated apically on the inner side; segment 2 very

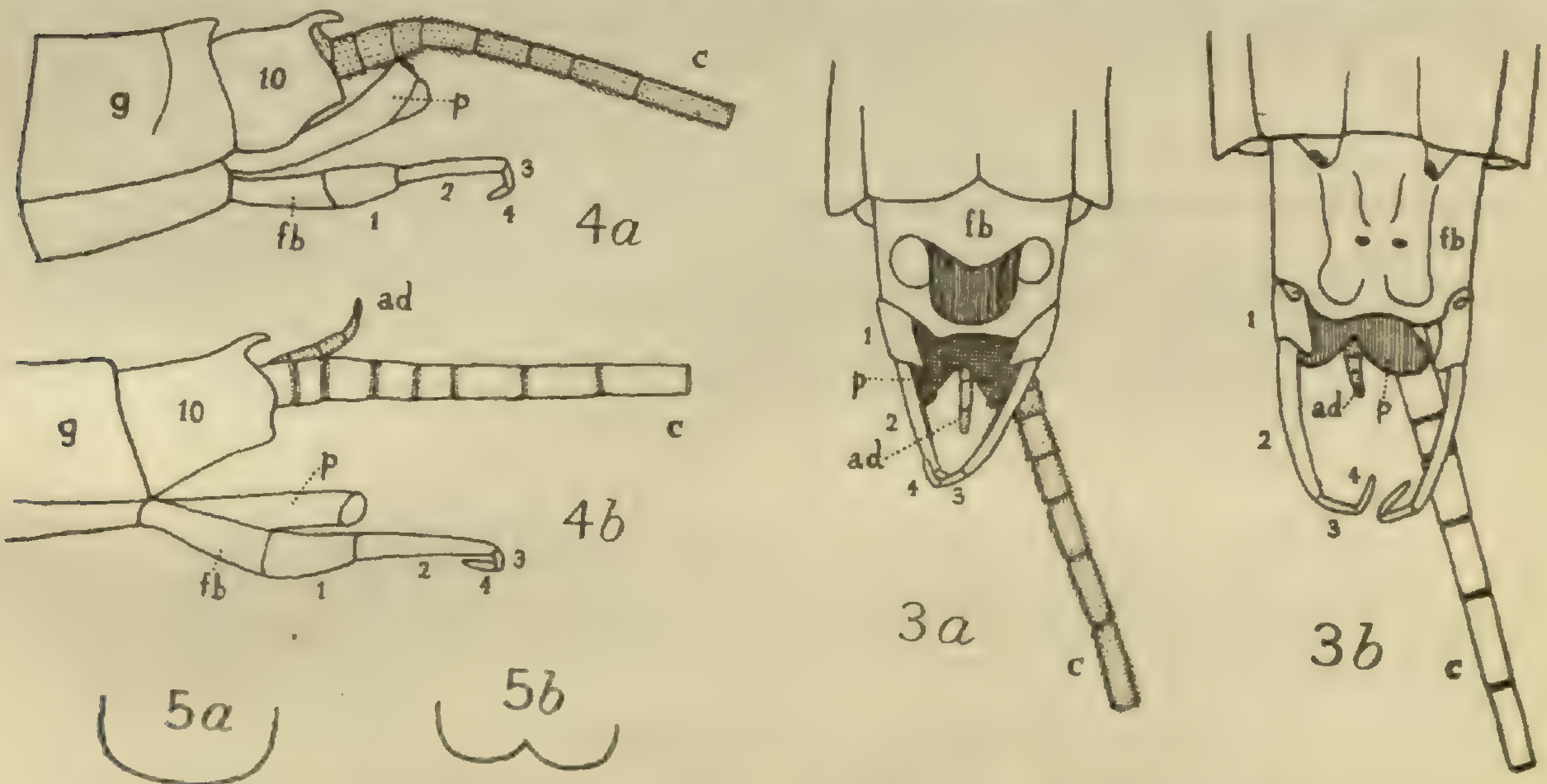


FIG. 3.—Ventral view of male appendages in the genus *Ichthybotus* Eaton: *a*, in *I. bicolor* n. sp.; *b*, in *I. hudsoni* McL. × 14. 1, 2, 3, 4, the four segments of the forceps; 9, 10, the last two abdominal segments; *ad*, appendix dorsalis; *c*, cercus (the right cercus is omitted); *fb*, forceps basis; *p*, penis.

FIG. 4.—Left lateral view of male appendages in the genus *Ichthybotus* Eaton: *a*, in *I. bicolor* n. sp.; *b*, in *I. hudsoni* McL. × 14. Right cercus and right forceps omitted. (For lettering see fig. 3.)

FIG. 5.—Outline of ventral valve in the female of *a*, *Ichthybotus bicolor* n. sp., and *b*, *I. hudsoni* McL. × 14.

long (but not so long as in *I. hudsoni* McL.), narrower, and with a row of minute hairs along the basal two-thirds of the inner margin; segments 3–4 very short, subequal. Penis more prominently lobed than in *I. hudsoni* McL., each lobe carrying a set of minute stiff hairs. Cerci 23 mm. long, dark chocolate-brown, strongly formed, slightly hairy, the segments cylindrical with narrow black basal rings; those of *I. hudsoni* McL. are quite hairless, yellowish-brown or orange-brown, with broad dark basal rings. Appendix dorsalis vestigial, 1 mm. long, with few segments.

In order that a careful comparison may be made between the appendages of the males of the two species, I have figured them both ventrally in fig. 3, and laterally in fig. 4.

The male may at once be distinguished from that of *I. hudsoni* McL. by its very dark coloration and its brown hindwings, as well as by the morphological differences given for the appendages.

♀. *Subimago:* Total length, 16·5 mm.; forewing, 19 mm.; hindwing, 7 mm.; expanse, 40 mm. Generally resembling the same stage in *I. hudsoni* McL., but with the following differences: The whole body, legs, and appendages are a dull earthy greyish-brown; the forewing has the ground-colour pale-greyish tinged with yellowish, the pale basal patch pale orange, the costal band dull purplish-brown, and the two oblique clouds a medium fuscous and more sharply angulated below R_1 than is the case in *I. hudsoni* McL.: the hindwing is dull purplish-brown, paler towards the base and posterior margin. (In *I. hudsoni* McL. the hindwing is pale-greyish, with two oblique clouds of medium fuscous.) Ventral valve entire, not bilobed as in *I. hudsoni* McL. (fig. 5). Cerci 8 mm.; appendix dorsalis 6·5 mm. long.

Types.—Holotype male imago and allotype female subimago in Cawthron Institute collection.

Locality.—Maitai River, Nelson; taken by Mr. A. Philpott on 29th December, 1920. No further specimens have so far been found, but the larva was taken in the following January by Mr. Philpott and myself, by scraping away the loose rubbly bank of the stream. It seems probable that this species may be found widely distributed throughout the South Island if searched for.

Art. 21.—*On some New Zealand Cave Orthoptera.*

By L. Chopard, D.Sc.

Communicated by H. Hamilton.

[*Read before the Wellington Philosophical Society, 7th June, 1921; received by Editor, 9th June, 1921; issued separately, 17th February, 1923.*]

Since the appearance of Hutton's important papers on the Stenopelmatidae of New Zealand nothing has been published on the Orthoptera living in the limestone caves of New Zealand.* All, therefore, that this author said in his first paper concerning those insects can still be considered as true. Speaking of the various species of Rhaphidophorinae found in caves, Hutton said, "The cave wetas are in the greatest confusion, and we do not know whether there are six or only two species."

This confusion is due to the fact that most of those species are known from a few examples only, and have generally been quite insufficiently described. Dr. J. Allan Thomson, Director of the Dominion Museum, Wellington, having kindly sent me for examination a small number of insects recently collected, I have had available a comparatively large amount of material, including fourteen specimens, belonging to three species, from the British Museum, very kindly communicated by Dr. Urarof. Besides this, Professor R. Ebner was recently good enough to send me the types of Rhaphidophorinae of Brunner's collection, among which I found *Neonetus*

* F. W. Hutton, The Stenopelmatidae of New Zealand, *Trans. N.Z. Inst.*, vol. 29, pp. 208–42, pl. 12–13, 1897; and Notes on some New Zealand Orthoptera, *Trans. N.Z. Inst.*, vol. 32, pp. 19–21, 1900.

variegatus Br., an interesting, insufficiently known species, which, although living outside caves, is very nearly allied to the true cavernicolous *Pleioplectron*.

In spite of these favourable conditions, I have not been able to consider all the species known as cave-dwellers in New Zealand, and therefore I cannot give a full synopsis of them. I shall endeavour to give as complete a description as possible of all the forms I have before me, and call the attention of the New Zealand entomologists to the fact that many particulars are still wanting on this interesting fauna.

Genus PACHYRHAMMA Br.

As far as I am aware, no representative of this remarkable genus has until now been found in the South Island. I do not think there is more than one species in the North Island, although local varieties may possibly exist.

Pachyrhamma fascifer Walk.

Kaiparora (Wellington), 16th March, 1917; one male, one female. Karori (Wellington), (cave), 1916; two females, two males; one young male, two young females.

A good redescription of this species has been given by Hutton,* to which need only be added that the subgenital plate of the female is small, triangular, presenting a wide semicircular notch at apex, the ovipositor rather longer than the body, almost straight, its inferior valves showing before the apex 10 small transverse ridges.

The number of spines of the legs is somewhat variable, as shown by the following table :—

	—	Fore Fem.	Fore Tib.	Mid. Fem.	Mid. Tib.		Post. Fem.	Post. Tib.
					Above.	Beneath		
♂	Int. marg. ..	6—4	4—4	3—4	6—5	4—4	8—10	32—30
	Ext. marg. ..	0—0	4—4	3—3	4—4	4—4	4— 4	34—33
♀	Int. marg. ..	4—4	4—4	3—3	4—4	4—4	11—11	29—31
	Ext. marg. ..	0—0	4—4	1—2	3—3	4—4	4— 4	35—36
♀	Int. marg. ..	4—6	4—4	2—1	3—5	4—4	8—10	28—32
	Ext. marg. ..	0—0	4—4	2—0	2—3	3—3	5— 4	34—37
♂	Int. marg. ..	5—5	4—4	2—2	4—4	4—4	8— 8	27—28
	Ext. marg. ..	0—0	4—4	2—1	3—3	4—4	3— 4	33—32
♂	Int. marg. ..	7—7	4—4	2—3	4—4	4—4	8—10	35—28
	Ext. marg. ..	0—0	4—4	2—2	3—3	4—4	3— 4	40—38
♂	Int. marg. ..	4—?	4—?	4—4	3—4	4—4	8— 9	28—29
	Ext. marg. ..	0—?	4—?	2—3	5—3	4—4	4— 5	32—33

The high specialization of the antennae of the males in this species proves somewhat different according to the specimens examined. In some of them the joints are cylindrical and smooth to about the sixtieth; they begin then to show a small apical tooth beneath till about the hundredth joint. This tooth becomes stronger but irregular towards the apex of the differentiated region, which region ceases abruptly, the joints again becoming cylindrical and very hairy. In others the joints are differentiated from the twentieth on, showing alternately small and

* *Loc. cit.*, vol. 29, p. 231.

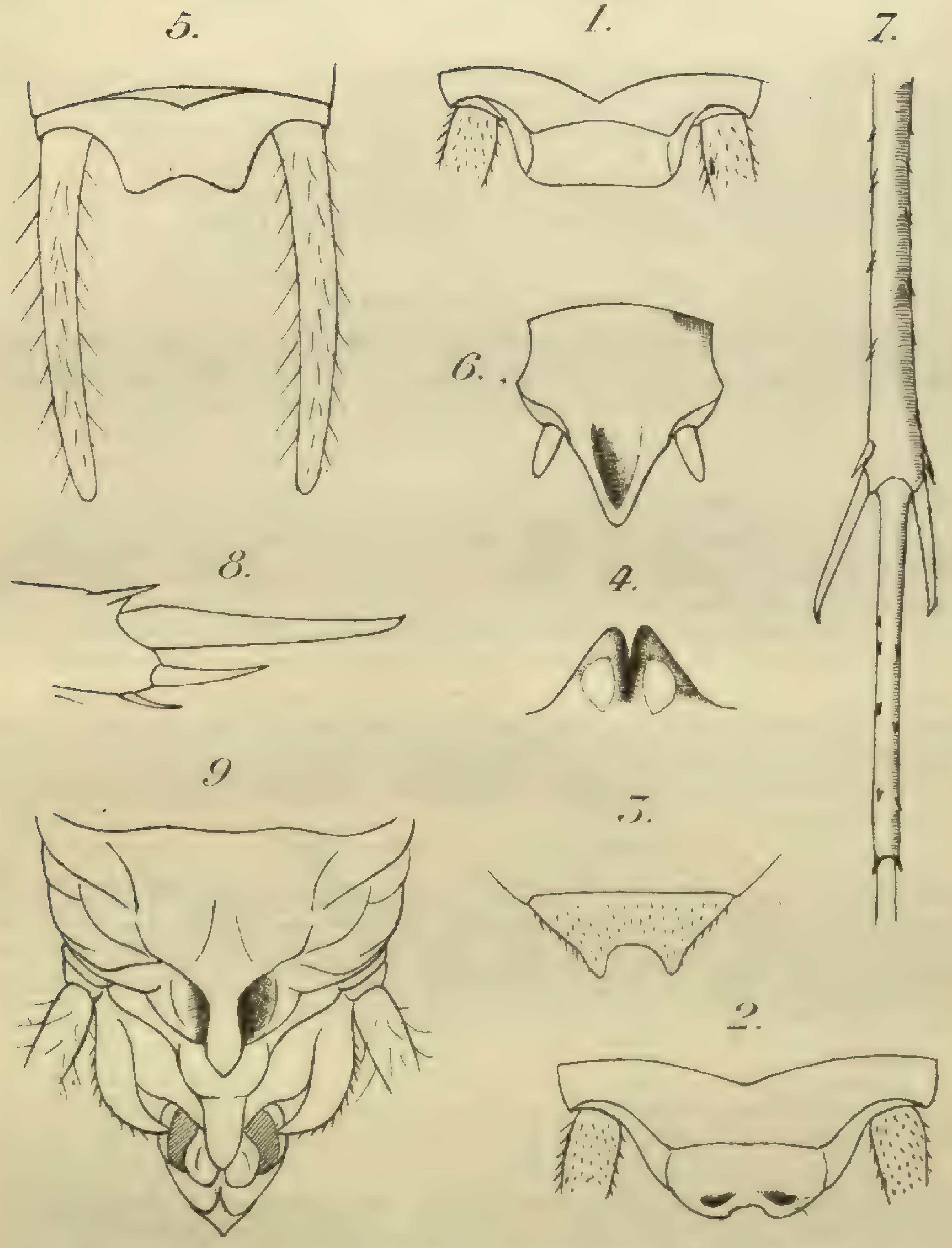


FIG. 1.—*Pachyrhamma fascifer* Walk.: supra-anal plate of male, × 7.
FIG. 2.—*Pachyrhamma fascifer* Walk.: supra-anal plate of female, × 7.
FIG. 3.—*Pachyrhamma fascifer* Walk.: subgenital plate of female, × 7.
FIG. 4.—*Pleioplectron cavernae* Hutt.: frontal rostrum, × 14.
FIG. 5.—*Pleioplectron cavernae* Hutt.: supra-anal plate and cerci of male, × 7.
FIG. 6.—*Pleioplectron cavernae* Hutt.: apical subgenital plate of male × 7.
FIG. 7.—*Pleioplectron cavernae* Hutt.: apex of left posterior tibia and metatarsus, × 7.
FIG. 8.—*Pleioplectron cavernae* Hutt.: external spurs of posterior tibiae, × 14.
FIG. 9.—*Weta thomsoni* n. sp.: apex of abdomen of male (inferior face), × 14.

large teeth until the seventieth or eightieth joint, where the antennae become cylindrical and hairy as stated above. In immature specimens the antennae show no differentiation whatever, appearing very much like those of the female, but rather thicker at base.

These differences seem quite individual; whilst another character may be considered as a real male dimorphism, as formerly related by Griffin among Stenopelmatids.* The two adult males found at Karori present a rather bigger head, with larger, strongly-notched eyes, and antennae thicker at base. They really seem somewhat different from the males of Kaiparora, but, both unfortunately lacking the apex of the abdomen, it is impossible to state whether they differ in other characters.

It may be added that *P. fascifer* does not seem to be exclusively cavernicolous, as I received a female from Mana Island which has certainly been caught outside of caves. Very likely the species has a mode of living similar to that of our European *Dolichopoda* or *Troglophilus*.

Genus PLEIOPLECTRON Hutt.

Pleioplectron cavernae Hutt.

Cave near Taupo, F. W. Hutton, 18th February, 1899; one male, one immature female (British Museum).

A few peculiarities must be added to Hutton's description of this species.

Frontal rostrum narrow, compressed, deeply and very narrowly notched at apex; palpi almost white, maxillary palpi not very long, with fourth joint equal to third, fifth once and a half as long as fourth (length of the three joints, 2 mm., 2–2 mm., 5–3 mm., 5 mm.). Anterior femora without apical spines or with a very small internal one; tibiae hairy, with 2 apical spurs and 3 spines on each inferior margin. Middle femora with a short external apical spine and a rather long, movable, internal one; tibiae with 4 apical spurs, 4 spines above (3 external, 1 internal), and 3 on each inferior margin. Posterior femora armed with a small genicular internal spine, 6–7 rather strong ones on the inferior internal margin, and only 2 small ones near the apex of the external margin; tibiae cylindrical and glabrous, presenting a brown ring near the base, and armed on each superior margin with 25–30 very small, brown, widely-separated, irregular spines, the last of which is apical; spurs short, the external a little longer than the internal ones, inferior ones very short, spiniform, intermediate half as long as the superior ones. Tarsi long, almost glabrous, very little compressed beneath, rounded above, first and second joints with 2 apical spines; metatarsus as long as other joints together, armed with 4–6 small spines, on two rows, besides the 2 apical ones.

Tenth tergite of male large with its posterior margin wide, weakly concave, rounded angles; anal valves very small; subgenital plate large, presenting a basal part wide and little convex, and an apical one projecting between the styles, triangular, subacute at apex, furrowed beneath; styles very short, cylindrical, inserted about on the middle of the lateral margins of the plate. Cerci rather long, straight, almost as thick at apex as at base.

I have seen no adult female, but the subgenital plate of the immature one shows a rounded notch at the apex.

* Stenopelmatids in F. SARAGIN et I. ROUX, *Nova Caledonia, Zoologie*, I, 4, p. 296.

If it is not an accidental disposition of the specimen here described, this species shows a very remarkable character in the apical spurs of the posterior tibiae; I think it is quite an exception in the whole group of the Rhaphidophorinae to have the internal spurs shorter than the external ones. If this feature be confirmed by examination of other specimens I should not hesitate to consider it as of generic value; but it seems so extraordinary that I cannot decide the question, chiefly from the fact that only one leg of the two specimens I have seen was in good condition for study.

I cannot follow Hutton's conclusions as to the synonymy of this species with *Pachyrhamma edwardsii* Br. (*non* Scudd). Brunner's description of the latter species runs as follows: "Femora antica subtus inermia, postica longissima, gracillima, subtus margine interno spinis 4–6 longioribus, margine externo spinulis minimis confertissimis armata." This character is in absolute contradiction with what we observe and what Hutton himself has described in *P. cavernae*.

Genus Weta* n. gen.

Frontal rostrum very narrow, truncated and feebly notched at apex; antennae very close at their base. Lateral lobes of pronotum only moderately high, their inferior margin straight. Cerci rather short and thick, little acute at apex. Anterior and middle femora armed with 2 acute movable spines, fore and middle tibiae with 4 apical spurs; posterior femora rather short, unarmed beneath, bearing a short internal genicular spine; posterior tibiae rather pubescent, armed with about 35 irregular spines; 4 apical spurs only, of which the supero-internal are longer than half the metatarsus. Male: Seventh, eighth, and ninth abdominal sternites partially united, and with the genital valves form a very remarkable genital complex. Female: subgenital plate small, ovipositor rather long, almost straight.

Genotype.—*Weta thomsoni* n. sp.

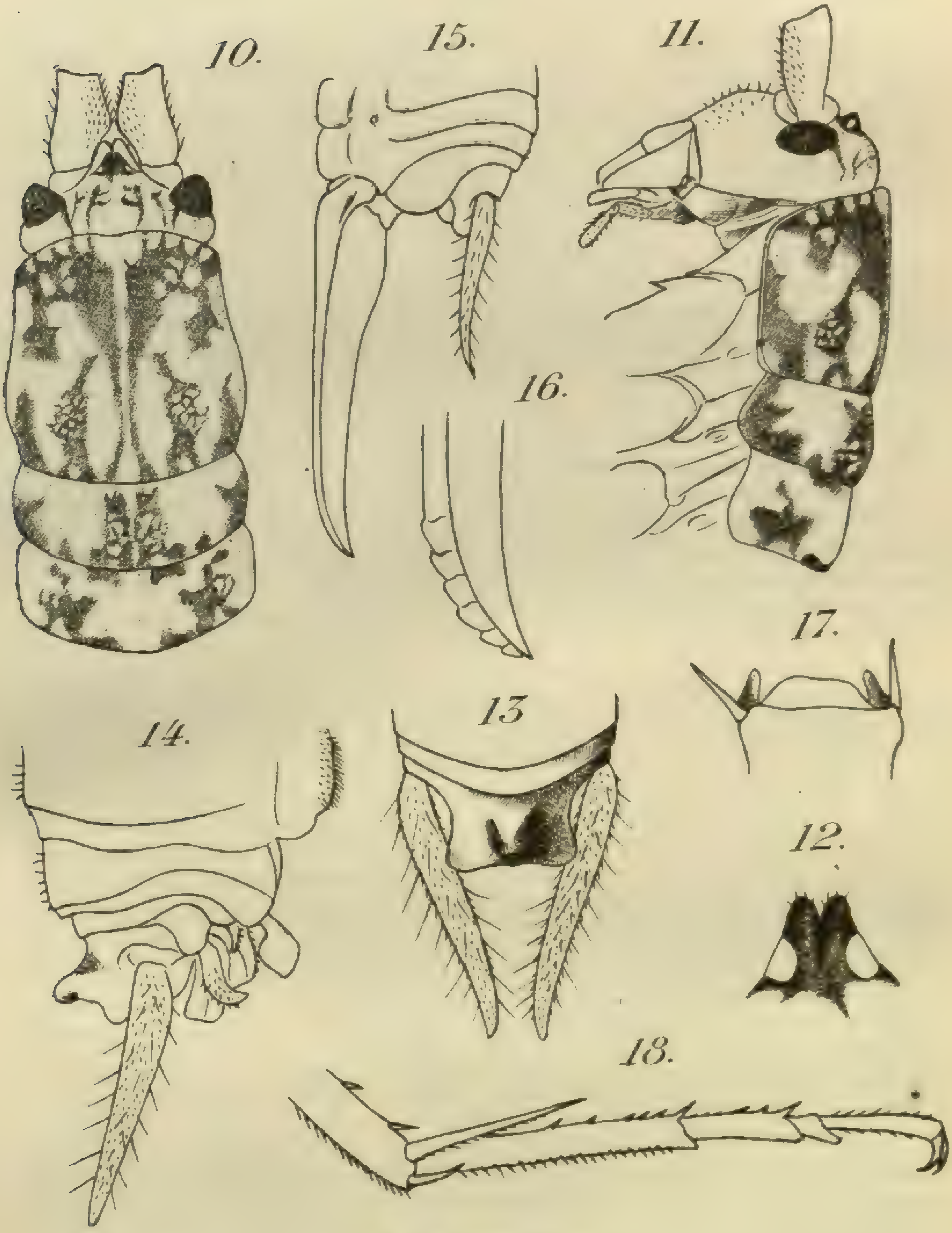
This genus takes place between *Miotopus* Hutt. and *Neonetus* Br., having movable acicular spines at apex of fore and middle femora and 4 apical tibial spurs; but the most remarkable feature consists in the form of male genitalia, which alone would need the creation of a new genus for the species.

Weta thomsoni n. sp.

♂. Medium-sized, rather slender species, with shining teguments, rather scarce pubescence, coloration yellowish, marbled with brown.

Head as large as the pronotum, yellowish; occiput convex, rather long, presenting a fine brown line behind each eye; frontal rostrum brown, very narrow, truncated and little notched at apex, furrowed on its whole length; two very neat ocellar spots at its base. Face yellow, with golden rather abundant pubescence; a rather large, badly defined brown spot beneath each antenna. Eyes small, black, situated rather high behind the antennae. Mouth-parts short; maxillae with 2 apical and very slender ante-apical teeth; palpi whitish, with first joint short, second rather long, third long and rather thick, fourth equal to third, fifth long, little curved

* Maori name of the Rhaphidophorinae.



Weta thomsoni n. sp.

FIG. 10.—Head and thorax, dorsal view, × 5.
FIG. 11.—Head and throax, lateral view, × 5.
FIG. 12.—Frontal rostrum, × 14.
FIG. 13.—Apex of abdomen of male, dorsal view, × 7.
FIG. 14.—Apex of abdomen of male, lateral view, × 7.
FIG. 15.—Apex of abdomen of female, lateral view, × 3.
FIG. 16.—Apex of ovipositor, × 7.
FIG. 17.—Apex of fore femur, × 14.
FIG. 18.—Apex of posterior tibia and tarsus (internal face), × 6.

(length of the three last joints, 2 mm., 5–2 mm., 5–4 mm.). Labium with basilar square, mentum very short, palpiger scarcely longer than wide, lobes short, the internal very acute, the external ones a little truncated; palpi with second joint rather long, thick, third a little enlarged at apex, almost as long as the other two together. Antennae contiguous at base, rufous almost glabrous at base, brown, pubescent at apex; antennae-sockets touching each other on the median line, first joint very large, wider at base than apex, second joint short but rather thick, the following cylindrical in both sexes.

Pronotum with anterior and posterior margins little convex, lateral lobes only moderately high, with inferior margin straight, anterior angle very rounded; coloration yellowish-rufous with a large fuscous median spot, extending on the sides forwards; median line light; on each side a brown spot is seen on the lateral lobes and backwards. Mesonotum with posterior margin little convex, lateral lobes very moderately high, their margin weakly convex; colour as on the pronotum. Metanotum with posterior margin straight, lateral lobes almost absent, presenting a large brown irregular spot on each side.

Abdomen rather slender, each tergite adorned with brown spots, these being more extensive and darker on the first tergites than on the apical ones, where they are limited to the posterior margin; this margin is slightly concave on the tergites 6 to 8, the ninth strongly convex; tenth tergite large, mixed with the supra-anal valve, forming a plate almost square, with its sides decidedly concave, bearing a big rounded tubercle in the middle; inferior anal valves small, brown, with inferior face ending in an acute angle.

Inferior surface of abdomen yellowish, pubescent; sternites regular to the sixth, but presenting from the seventh extremely remarkable formation. These three sternites join to form the subgenital plate and are partially joined together; they are a little contracted in comparison with the preceding, and in direct contact with the corresponding tergites, without any connecting membrane; seventh sternite a little raised on the sides, presenting a slight median prominence ending in a process projecting in the form of a compressed disc; eighth short, almost joined with the preceding and presenting 2 small apical points under the process in question; ninth sternite wholly joined with the genital valves, which are strongly chitinized; no styli.

Cerci rather short and thick, a little curved, almost rounded at apex.

Anterior and middle legs ringed with brown, feebly pubescent. Anterior coxae armed with a short strong spine; femora adorned with 3 wide brown rings and armed with 2 apical rather short but movable spines; tibiae darkened at base and presenting 2 very large brown rings in the middle and at apex; 4 apical spurs, very fine and acute, the superior short, the inferior ones much longer; each inferior margin armed with 2–3 spines. Intermediate legs showing the same ornamentation and armature as the anterior ones. Tarsi with metatarsus very long, chiefly the anterior ones, presenting beneath two rows of small spinules to the apical third, carinated from there to the apex, second and third joints carinated beneath Posterior femora rather short, enlarged at base, unarmed beneath, presenting a small genicular internal spine; tibiae longer than the femora, armed above on each margin with about 35 somewhat irregular spines, very small and contiguous at base, becoming a little longer and more remote towards

the apex ; in the middle of the tibiae the spines are disposed in short series, as shown by the following formulae :—

11—3—2—3—4—2—2—3—2—2—1—1—1—1—1 = 39.
11—4—3—2—2—1—1—2—1—2—1—1—2—1—1—1 = 36.

Only 4 apical spurs, the inferior not half as long as the superior ones, the latter very long, extending over the half of the metatarsus ; this (the metatarsus) is armed above with two rows of 4 to 6 small spines, the first of which is rather distant from the others, the pair nearer the apex the stronger ; beneath it bears two rows of very small spinules almost to the apex ; second joint armed above with 3–4 spines on each margin. The posterior legs are rather pubescent.

♀. In general shape and colour similar to the male ; supra-anal valve smaller, quadrangular, somewhat notched at apex, presenting a slight median elevation ; subgenital plate very small, almost hidden between the seventh sternite and the base of ovipositor, rounded or little notched at apex. Cerci as in male but slightly more acute at apex. Ovipositor moderately long, almost straight, little enlarged at base, curved and acuminate at apex ; inferior valves with 7 rather strong denticulations, superior ones longitudinally striated outside, acute at apex.

Length of body, ♂ 23 mm., ♀ 18 mm. ; pronotum, ♂ 5 mm., ♀ 4·5 mm. ; anterior femora, 9·5 mm. ; anterior tibiae, 9·5 mm. ; internal femora, 9·5 mm. ; internal tibiae, 9·5 mm. ; posterior femora, 15 mm. ; posterior tibia, 19 mm. ; posterior tarsus, 9 mm. ; posterior metatarsus, 4·7 mm. ; superior internal spur, 3 mm. ; cerci, 3·6 mm. ; ovipositor, 10 mm.

I take pleasure in naming this species in honour of Dr. J. Allan Thomson.

Types.—One male, one female, from limestone cave, Opihi River, near Raincliff, South Canterbury, 4th May, 1917.

Co-types.—Male and female, same locality.

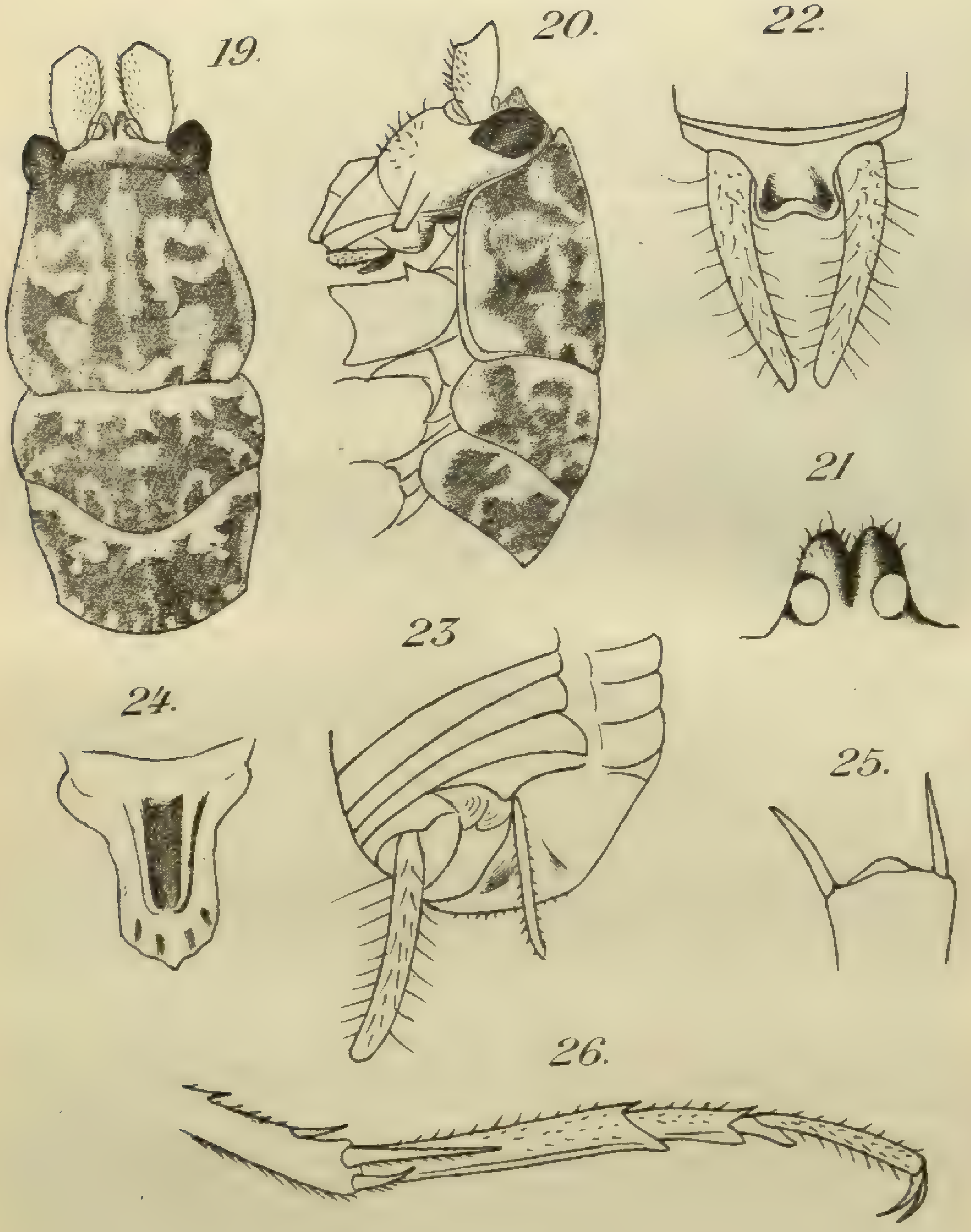
Genus NEONETUS Br.

This genus was established by Brunner von Wattenwyl for a small species which the said author described so briefly that it was quite impossible to recognize it when a second species of the genus was discovered subsequently. For that reason Hutton thought it best to select the commonest species as type of the genus, and consequently selected *N. variegatus* Br. As I stated, I had the opportunity of examining Brunner's types, and I found that his *variegatus* was quite different from what Hutton had thought it, and was much more closely related to *pilosus* Hutt. ; the form of the subgenital plate of the male seems very comparable in both species, but *variegatus* does not show the abundant hair-clothing given by Hutton as characteristic of his *pilosus*. A full redescription of *N. variegatus* Br. seems therefore necessary.

Neonetus variegatus Br.

Neonetus variegatus Brunner, 1888, *Verh. zool. bot. Ges. Wien*, xxviii, p. 300, pl. 7, fig. 27 (*non* Hutton, 1897).

Rather small species, with a testaceous-brown coloration marbled with numerous light, dark-brown-circled spots ; pubescence rather scarce. Head small, rounded ; frontal rostrum very narrow, compressed, forming two small tubercules, little acute, truncated, and feebly divided at apex, deeply furrowed above ; face yellowish with a brown spot beneath each eye and a wide brown band on each side from the antennal socket to



Neonetus variegatus Br.

Fig. 19.—Head and thorax, dorsal view, × 7.
Fig. 20.—Head and thorax, lateral view, × 7.
Fig. 21.—Frontal rostrum, × 14.
Fig. 22.—Apex of abdomen of male, dorsal view, × 7.
Fig. 23.—Apex of abdomen of male, lateral view, × 9.
Fig. 24.—Chitinized part of genitalia, × 14.
Fig. 25.—Apex of anterior femur, × 19.
Fig. 26.—Apex of posterior tibia and tarsus (internal face), × 14.

the clypeus. Maxillary palpi rather short, with first and second joints white, third and fourth spotted with brown, fifth whitish; fourth joint little shorter than third, fifth scarcely twice as long as fourth (1 mm., 5–1 mm., 2–2 mm.); labial palpi whitish. Eyes rather large, much rounded posteriorly, situated behind the antennae near the top of head; ocellary spots very near the base of the rostrum. Antennae rufous, about three times as long as the body, showing from place to place a few lighter rings; first joints short, wide, rather distant from one another.

Pronotum with anterior and posterior margins feebly convex, lateral lobes only moderately high, their inferior margin almost straight, rounded angles; disc little convex, brown with yellowish spots, lateral lobes fuscous widely bordered with yellowish inferiorly. Mesonotum and metanotum coloured like the pronotum, with posterior margin little convex, inferior margin of lateral lobes rounded. Espisterna and epimera short, yellowish.

Abdomen brown, variegated with yellow, the tergites presenting posteriorly a darker band interrupted by light spots; first tergite presenting a large yellowish mark on each side. Inferior face of abdomen yellowish. Male: Supra-anal valve square, subgenital plate very large, ending in a long, curved, acute process; styli very long and slender, inserted near the base of the plate; cerci rather long, curved, thick at apex; genitalia presenting no real epiphallus but a small lanceolate plate, partially chitinized. Female: Tenth tergite large, truncated; supra-anal valve small, rounded; subgenital plate small, incised at apex; cerci rather short, acute at apex; ovipositor relatively short and wide, curved from the base, acute at apex, inferior valves presenting about 10 denticulations at apex, superior margin of the superior valves very finely denticulated in its apical third.

Legs marbled with brown, little pubescent; anterior and intermediate femora with 3 or 4 brown bands, armed at apex with 2 rather short but movable spines (a little longer at the intermediate femora); tibiae with 3 brown rings, armed with 2 inferior apical spurs and 2 spines on each inferior margin; posterior femora rather thick, varied with brown chiefly on their internal face, inferior margins armed with 4 spines each, apex unarmed; tibiae longer than the femora, armed on each superior margin with 20 to 25 rather regular, moderately strong spines, the last of each row apical; 4 apical spurs only, the supero-internal a little longer than half the metatarsus. All the tarsi hairy above, carinated, glabrous beneath; posterior metatarsus armed with 2 apical spines as well as the second joint.

Length of body, 12 mm.; pronotum, 3 mm.; posterior femora, 9·5 mm.; posterior tibiae, 11·5 mm.; ovipositor, 6·5 mm.

Neonetus huttoni nom. nov.

Neonetus variegatus Hutton, 1897, *Trans. N.Z. Inst.*, vol. 29, p. 236, pl. 13, 16–16*c*.

As explained above, a new name is necessary for this species, which is absolutely different from Brunner's *N. variegatus*.

Art. 22.—*Some New Zealand Amphipoda: No. 3.**

By Chas. Chilton, M.A., D.Sc., F.N.Z.Inst., &c.

[*Read before the Philosophical Institute of Canterbury, 7th December, 1921; received by Editor, 31st December, 1921; issued separately, 17th February, 1923.*]

Amphilochus squamosus (G. M. Thomson).

Amphilochus squamosus Stebbing, 1906, p. 161; 1910, p. 577; Chilton, 1912, p. 479. *A. marionis* Stebbing, 1906, p. 151 and p. 723. *Gitanopsis antarctica* Chevreux, 1913, p. 104.

This species is fairly common on the New Zealand coasts; it is small, not exceeding 4 mm. in length. It was described and figured by Thomson in 1880, but, owing to insufficient information as to the mouth-parts, was given as a doubtful species in "*Das Tierreich*" *Amphipoda* in 1906, not "accidentally omitted," as I stated by mistake in 1912. In that year I was able to compare specimens from New Zealand with others from the South Orkneys collected by the "Scotia," and came to the conclusion that they were specifically identical. I also identified them with *A. marionis* Stebbing obtained by the "Challenger" from Marion Island, and drew attention to the presence of a small accessory flagellum on the upper antennae which had not been mentioned by previous authors. I omitted, however, to point out that the molar of the mandible is well developed, not "feeble" as described by Stebbing in the generic diagnosis given in 1906 (p. 149). Stebbing (1888, p. 744) says, "the molar tubercle (not shown in the figures, *m*, *m*) is conical, scarcely if at all dentate." In the specimens I have examined it is fully as strong as shown in Chevreux's figure of *Gitanopsis antarctica*, and has the circular end thickly provided with short stout setules forming a triturating surface in the usual manner.

Gitanopsis antarctica, described from Petermann Island by Chevreux in 1913, agrees in the presence of the accessory flagellum and in the well-developed molar as well as in the other characters. Through the kindness of Monsieur Edouard Chevreux I have been able to examine a specimen of his species, and cannot find any character of importance in which it differs from the New Zealand or South Orkneys ones.

Stebbing (1910, p. 577) records the species under the name *Amphilochus marionis* from "Off Manning River," New South Wales, and states that the species is notable for having the telson much shorter than in other species of the genus except *A. brunneus* Della Valle. The species thus appears to be circumpolar in Subantarctic and Antarctic seas.

Whether the species should be left in *Amphilochus* or transferred to *Gitanopsis* is doubtful; I am inclined to think that the differences in the mandibles and other points are not of generic value, and this seems to be confirmed by the fact that in Australian specimens that seem undoubtedly to belong to *Amphilochus neapolitanus* Della Valle the molar is well developed, and not feeble as it is in European specimens of that species. I am dealing more fully with these species in a paper sent to the *Records of the Australian Museum.*

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* For No. 1 of this series see *Trans. N.Z. Inst.*, vol. 52, p. 1, and for No. 2 *Trans. N.Z. Inst.*, vol. 53, p. 220.

Metopella ovata (Stebbing).

Metopella ovata Stebbing, 1906, p. 183; Chilton, 1912, p. 481.

I have two small specimens from Brighton, Otago, which I refer to this species. One is a female, about 3 mm. in length, and agrees closely with Stebbing's description and figures; it has the palm of the second gnathopod transverse, and that of the first nearly so; in these respects it agrees with the South Orkneys specimens that I referred to *M. ovata* in 1912, with one of which I have been able to compare it. The other Brighton specimen, taken at approximately the same time, shows no brood-plates or other distinctive marks of sex, and is possibly a male; in it the palms of both gnathopods are much more oblique; it agrees so closely in all other respects that I think it must be considered as belonging to the same species.

In both specimens, which have been stained with eosine and mounted in Canada balsam as micro-slides, certain structures which appear to be of a glandular nature have been deeply stained in the side-plates and other parts of the body but not in the appendages; these show as groups of small round bodies with straight ducts leading towards the margin of the side-plate. They appear to be similar to the structures figured by Stebbing (1891, pl. 1, *prp.* 4) in the basal joint of the fourth peraeopod of *Urothoe elegans*, though I cannot find that these are referred to in his text.

Metopella ovata is now known from the South Orkneys, the Strait of Magellan, and from New Zealand.

Paracalliope fluviatilis (G. M. Thomson).

Calliope fluviatilis G. M. Thomson, 1879, p. 240, pl. x, *c*, fig. 4 *a–c*. *Pherusa australis* Haswell, 1880, p. 103, pl. 7, fig. 1. *Paracalliope fluviatilis* Chilton, 1909, p. 55; 1920, p. 513; 1921, p. 529.

This species is the one commonly found in fresh-water streams throughout the whole of New Zealand. I have numerous specimens from fresh water at Cape Maria van Diemen, sent me by Mr. T. B. Smith, and have collected the species myself in various streams in Southland and at many intermediate stations. As has already been pointed out, the species is, however, capable of living in brackish and even in quite salt water, occurring in Dunedin Harbour, and also in Auckland Harbour, whence I have two specimens collected near the Puhoe Beacon.

In the Amphipoda of Chilka Lake, on the east coast of Bengal, which I have recently been examining, this species was represented by numerous specimens from different parts of the lake, and there were also specimens from Adyar River, from the outskirts of the city of Madras. Specimens sent from Nasugbu, south coast of Luzon, Philippine Islands, by Professor C. F. Baker, also proved to belong to this species, though the character of the water in which they were living in the Philippine Islands was not recorded. I have little doubt that Mr. Stebbing is right in suggesting that *Pherusa australis* Haswell from the east coast of Australia also belongs to this species, though I have been unable as yet to obtain specimens for comparison, and the type of Haswell's species is not available. I have described and figured the species in some detail in my report on the Chilka Lake Amphipoda. It is readily recognized by the peculiar inverted character of the second gnathopods and by the greatly elongated fifth peraeopods.

The existence of this species in fresh and brackish water in India, Philippine Islands, Australia, and New Zealand is of importance from the point of view of geographical distribution.

Nototropis minikoi (Walker).

Paratylus minikoi Walker, 1905, p. 925, fig. 141, 1–5.

Locality : Puysegur Point. One specimen, collected by T. B. Smith.

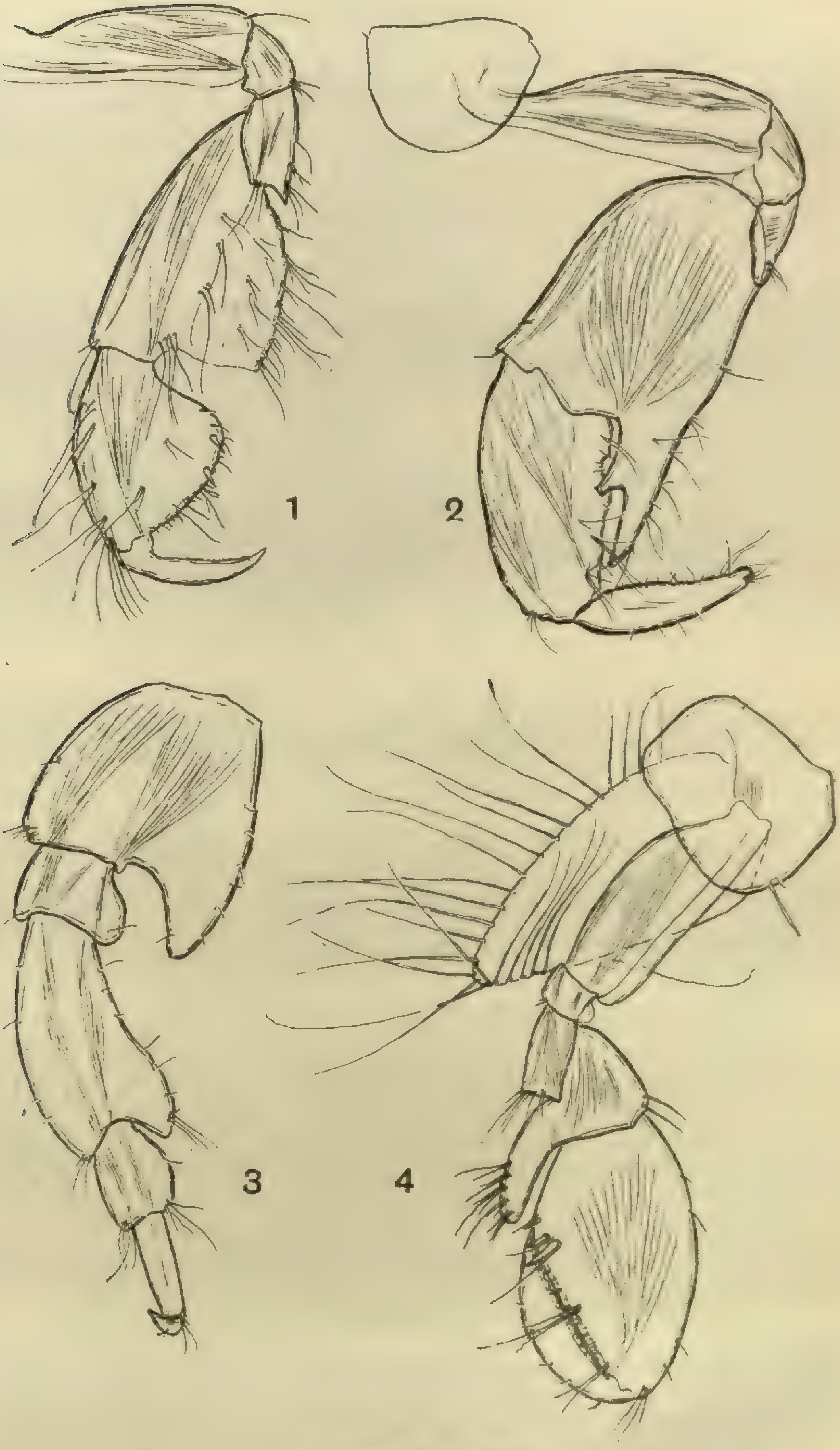
This species was originally described by Walker in his report on the Amphipoda of the Maldive and Laccadive Archipelagos. A small number of specimens collected at Carnac Island, west Australia, by Dr. Mjoberg, whose collection I have recently been examining, prove to belong to Walker's species, and the comparison of them with the single specimen from Puysegur Point which I had had for some time proved that the New Zealand specimen was also the same. This is the first record of the genus for New Zealand. The species *N. minikoi* can be distinguished from *N. homochir* (Haswell), which occurs in Australian and South African seas, by the absence of dorsal teeth on the peraeon and anterior segments of the pleon, and by the presence of a carina on the fourth and a smaller one on the coalesced fifth and sixth segments. The branchiae, described by Walker as "obliquely pinnate," are also characteristic, though the branchiae on the different segments vary somewhat in structure.

The species is now known from the Laccadive Archipelago, west Australia, and south-west New Zealand.

Ericthonius brasiliensis (Dana).

Ericthonius brasiliensis Stebbing, 1906, p. 671 (with synonyms).

This species has not hitherto been recorded from New Zealand, but I have a few specimens collected near D'Urville Rock, Hauraki Gulf, in December, 1914, that I think undoubtedly belong to it. They agree closely with the description given by Stebbing quoted above, and with the figures of *E. abditus* given by Sars (1894, pl. 215), this species being considered by Stebbing to be a synonym of *E. brasiliensis.* I have also been able to compare the New Zealand specimens with an English one which I presume to be a specimen of *E. brasiliensis* (Dana), and find that they agree in all essential points. In one respect, however, the New Zealand specimens appear to differ from *E. brasiliensis* as defined by Stebbing and to agree with *E. pugnax* Dana from the "Sooloo Sea"—viz., the third peraeopod has the second joint with a narrow acute downward prolongation of the hind-margin. The same character is possessed by *E. macrodactylus* Dana, also from the "Sooloo Sea," and I expect that it is one attained only in the older males, the younger ones having the joint of more normal shape as described by Stebbing. Stebbing says that *E. pugnax* is closely related to *E. brasiliensis,* and that *E. macrodactylus* is distinguished "from *E. difformis* especially by the long tooth of the fifth joint in the second gnathopod being separated from the base of the sixth joint by a very deep concavity, and by the second joint of the third peraeopod having a narrow acute prolongation of the hind-margin." Of *E. difformis* M.-Edw. (a species found in the North Atlantic) he says, "possibly not distinct from *E. brasiliensis.*" From the fact that the species occurring in New Zealand seems to combine characters of *E. brasiliensis* and *E. pugnax,* I strongly suspect that all the forms mentioned above really belong to the one species, the differences in the gnathopods and in the third peraeopods being merely due to different stages of growth. The figures given, which were drawn by Miss Herriott independently and before it was recognized that the species was the same as *E. brasiliensis,* will, I think,



Ericthonius brasiliensis.

FIG. 1.—Male, first gnathopod.
FIG. 2.—Male, second gnathopod.
FIG. 3.—Male, third peraeopod.
FIG. 4.—Female, second gnathopod.

bear out this statement. This conclusion seems to be confirmed by the fact that Walker (1904, p. 292) has recorded *E. abditus* (*i.e.*, *E. brasiliensis*) from Galle Harbour, where he says it is abundant, and from other localities on the coast of Ceylon; and that he also gives *E. macrodactylus* Dana, which is probably the same as *E. difformis* M.-Edw., from the Gulf of Manaar.

Ericthonius brasiliensis.

Fig. 5.—Female bearing eggs, second gnathopod (? abnormal).

While the males and females appear to agree closely with the figures given by Sars, it is to be noted that I have one specimen in which the second gnathopod has characters intermediate between that of the male and that of the female (see fig. 5). This specimen I would have considered without hesitation an immature male, but the appendage bears a well-developed brood-plate, and there are eggs in the brood-pouch.

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ART. 23.—*Additions to the Fish Fauna of New Zealand.*

By L. T. GRIFFIN, F.Z.S., Assistant Curator, Auckland Museum.

[*Read before the Auckland Institute, 19th December, 1921; received by Editor, 21st December, 1921; issued separately, 17th February, 1923.*]

Plates 20–26.

SINCE the publication of my last paper* many striking examples of fish have been received at the Museum, and an account of the most interesting will be found annexed hereto. There is yet much to be done before we may consider the knowledge of our local fishes to be anything like complete. At the present time trawling operations are limited to comparatively shallow areas round our coast, consequently we know but little of the possibilities of deep-sea trawling and the productions therefrom.

I am glad to take this opportunity to acknowledge my gratitude to the following gentlemen who are actively interesting themselves in my work: To Mr. T. F. Cheeseman, F.L.S., F.Z.S., Curator of the Auckland Museum, for many courtesies in connection with my ichthyological studies; and to Mr. Allan R. McCulloch, Zoologist to the Australian Museum, Sydney, on whose long experience and expert advice I make many and frequent calls. For specimens of fish: Sandford's Limited; Mr. P. Munro; Mr. G. C. Munro; Captain Nilsson, of the s.s. "James Cosgrove"; Auckland City Council Fish-depot; Mr. J. H. Deighton, late general manager; Captain McKay and Engineer Crawford, of the s.s. "Cowan"; Mr. G. R. Hodgkinson, of the nets department; and Mr. Bostock, mate of the s.s. "Simplon."

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* *Trans. N.Z. Inst.*, vol. 53, pp. 351–57, 1921.

Order HOLOCEPHALI (Ghost-sharks).

Family CHIMAERIDAE.

Genus Chimaera Linné.

Chimaera novae-zelandiae Fowler. (Plate 20, fig. 2.)

> *Chimaera monstrosa* var. *australis* Hector, *Trans. N.Z. Inst.*, vol. 34, p. 239, pl. xiv, 1902. *C. australis* Garman, *Mem. Mus. Comp. Zool.*, vol. 40, p. 88, 1911 (not *C. australis* Shaw). *C. novae-zelandiae* Fowler, *Proc. Acad. N. Sci. Philad.*, vol. 62, p. 603, 1911.

Although this species has been described, and figured by an outline drawing, in our literature, neither description nor figure can be considered as altogether satisfactory, many important details having been omitted. The possession of fresh specimens in fine condition gives me the opportunity of redescribing and refiguring this fish.

Body elongate, compressed, the caudal axis prolonged into a long filament. Head compressed, its length 5 in that between the tip of the snout and the posterior margin of the supracaudal fin. The upper profile of the male with a prominence before the eye on which is a small clasper 10 mm. long, distal end of which is formed into a flattened knob covered with small curved spines directed backwards, and when depressed fits into a small fleshy cavity on top of the head. Eye large, $3\frac{1}{2}$ in the head. Interorbital space convex, $1\frac{1}{4}$ as wide as the eye. Gills $3\frac{1}{2}$; 9 gill-rakers on the lower half of the anterior limb. Snout conical, nostrils situated above the margin of the upper jaw. Between the upper surface of the snout and the mouth are three rows of large open pores extending round the sides of the head; the lowest, which is situated above the mouth, is the longest. Pores also occur on other parts of the head and bordering the postorbital branches of the lateral line. Mouth inferior; tritors on the dental laminae in the form of rods.

First dorsal fin with its origin a little behind the vertical of that of the pectoral; it is furnished with a strong spine, the length of which is not quite so great as the depth of the head at the centre of the eye. It is keeled on its anterior edge, striated on sides, and serrated behind. When laid back it reaches beyond the middle of the interdorsal space. First dorsal ray longest, slightly longer than the spine; those following decrease somewhat rapidly in length backward. Interdorsal space as wide as the base of the first dorsal fin, and traversed by a low membrane which is highest anteriorly. Second dorsal fin low, its margin slightly concave, the median rays being shortest while those of the anterior portion are longest; its length is rather more than half that from the tip of snout to the distal end of the supracaudal. No anal fin.

Pectoral very broad, its breadth subequal to the space between the tip of the snout and the origin of the first dorsal fin; its length is somewhat greater. When laid back it reaches the vertical of the posterior angle of the base of the ventral. Ventral originating a little behind the origin of the second dorsal; the length of its anterior margin is rather more than half that of the upper margin of the pectoral. In front of the pelvic fins are the anterior claspers, which are retractile into shallow crescentic glandular pouches. Behind the fins the large bifid claspers are situated; they are very long, three times the length of the anterior claspers and about equal to the length of the ventral fin; the inner one is split along about half its

length and both claspers are almost wholly furnished with short spines directed backwards. Supracaudal very little shorter than the subcaudal, and about equal to it in height; the caudal filament is rather longer than the distance between tip of the snout and origin of the pelvic fin.

The lateral line forms first a concave, then a convex curve above the pectoral, and thence continues along the side slightly above the middle of the height by a series of very short waves until it reaches the hinder angle of the second dorsal. It then bends downward to the lower margin of the caudal axis, and extends along the filament until it is lost. The anterior portion of the lateral line system has several conspicuous ramifications about the head. Commencing at the postorbital junction with that of the body, it passes over the eye to the first line of pores on the upper part of the snout. A lower branch from the postorbital junction passes below the eye and unites with the middle line of rostral pores, and sends off two branch lines below the posterior border of the eye; the hinder branch reaches downward over the gill-cover, and the anterior one is directed towards the angle of the mouth. There is also a short branch line across the nape, which unites with the interorbital lines on each side, and forms an angle on the median line.

Colour.—Ground-colour cream, marbled with purplish-brown. A double line of bluish-white spots above the eye from the nape to the base of the snout. Light-buff blotches and spots of various shapes occur at short intervals along the margin of the back. Lateral line dull white. First dorsal spine white, its base streaked with brown; the rays and membrane are blackish-brown with a broad mesial white band. Second dorsal with a small dark patch on its anterior rays, and thence broadly margined with black, the bases of the rays much lighter. Caudal rays uniform blackish-brown; the filament white. Pectoral and pelvic fins brownish-grey. Eye silver-white and blue-black. Horny cap on top of the head cream in colour, streaked with brown.

Described from a male specimen, 442 mm. long from tip of snout to end of supracaudal: the filament is 246 mm. long.

In all, five specimens have been examined, of which four are females. The largest is 563 mm. long without the caudal filament, the latter being 210 mm. long.

Locality.—Trawled in the Tasman Sea, nine miles to the north of Kaipara Heads, within the Auckland Provincial District, July, 1921.

Family MYRIDAE.

Genus MURAENICHTHYS Bleeker.

Muraenichthys australis Macleay. (Plate 20, fig. 1.)

> *Muraenichthys australis* Macleay, *Proc. Linn. Soc. N.S. Wales*, vol. 6, p. 272, 1881; McCulloch, *Biol. Res.* "*Endeavour*" [vol. 1], pt. 1. p. 20, fig. 6, 1911.

Body cylindrical, vermiform, slender, its depth behind the gill-opening about 4 in the head and $\frac{1}{50}$ of the total length. The head rather more than 5 in the trunk and nearly $\frac{1}{12}$ in the total length. Eye small, 3 in the snout, the latter being broad, obtusely pointed, and $4\frac{3}{4}$ in the head. Cleft of mouth extends behind the eye, the distance from its angle to the posterior margin of the orbit being $1\frac{1}{2}$ times the diameter of the eye. Anterior nostrils in a tube placed near the tip of the snout, and provided

with a minute exterior lobe. A membranous flap overhanging the lips covers the posterior nostril, which is situated just before and below the eye.

Teeth cardiform, in a single row in the jaws, and a median row on the palate. A few longer ones are found on either side of the vomer covered by the lips. The anterior teeth of the mandible are a trifle longer than the posterior ones. A row of 3 pores on either side of the snout before the eye, another row of 3 on either side of the mandible. A single one on top of the head between the eyes, and another single pore on the lateral line above the gill-opening. Tongue immovable. Gill-opening small, about as wide as the eye; branchiostegal sac not greatly developed. Lateral line somewhat nearer the dorsal surface than the middle of the height; slightly arched above the branchial sac, thence bending downward towards the angle of the mouth, which it does not quite reach.

Vent placed nearer the head than the tip of tail, its distance from the snout being rather less than 1·4 in the tail.

Origin of dorsal fin a little posterior to that of the anal, and the distance from its origin to the vent about half the length of the head. Both fins are exceedingly low, almost rudimentary, but they broaden out slightly near the tip of the tail, which they surround. From the dorsal origin a groove is indicated all along the middle of the back, ending near the nape.

Colour.—Dorsal surface as far as or a trifle beyond the lateral line, pale golden-brown covered with clusters of minute darker-brown dots. Sides slightly lighter. Belly pale bluish-silver. On top of nape there is a thin transparent blood-red patch. Branchiostegal sac bright bluish-silver, with the radii slightly deeper blue. Eye bright silver and black. Tip of tail and lowest dorsal and anal rays lemon-yellow.

Described and figured from a living specimen, 247 mm. long, which was captured in Whangarei Harbour, Auckland District, by Mr. W. M. Fraser, Engineer to the Whangarei Harbour Board. Mr. Fraser informed me that he found it at a depth of 9 in. below the surface of a sandy mud-flat at low-tide mark, where the common marine grass grows.

Affinities.—The species was first described and named by Macleay from a specimen captured at Port Jackson, and later redescribed and figured by McCulloch from Macleay's original specimen. The only other one of this genus so far known to occur in New Zealand, and recorded by me in *Trans. N.Z. Inst.*, vol. 53, p. 351, pl. liv, fig. 1, 1921, is *M. breviceps*, which has several marked specific differences, particularly those in regard to the position of the dorsal fin and the form of the teeth. In *M. breviceps* the origin of the dorsal fin will be found not far behind the head, while its teeth are granular.

Locality and Distribution.—Whangarei Harbour, Auckland Provincial District; Lane Cove, Port Jackson.

Family EXOCOETIDAE.

Genus Cypselurus Swainson.

Cypselurus cribrosus Kner. Flying-fish. (Plate 21.)

> *Exocoetus unicolor* vel *cribrosa* Kner., *Reise* "*Novara*," Zool., i, p. 325, 1867. *Cypselurus cribrosus* McCulloch, *Mem. Qld. Mus.*, vol. 5, p. 59, pl. 7, 1916.

One specimen, 200 mm. long from the tip of the snout to the middle caudal rays, was received during the year, trawled in the Bay of Plenty.

A comparison of my specimen with McCulloch's description and plate shows they represent the same species, this being the first time it has been recorded from New Zealand. The two specimens examined by McCulloch are somewhat longer than the one before me, being 232 mm. and 235 mm. respectively; the difference in length is without doubt due to age only. All the fins in this species seem to be subject to considerable variation. McCulloch says the pectoral may reach either to the base of the caudal, or only to the end of the dorsal; the ventrals also vary in length. The anal may be as long as or shorter than the dorsal, and both the latter fins may have either eleven or twelve rays each.

Colour.—Deep ultramarine-blue above, the margins of the scales a little lighter. Sides bright silver from origin of pectoral to origin of ventral. Under-surface silver-white. Ventrals with light transparent membrane, their rays dusky or white. Pectorals dark without lighter cross-bands, but their margins and lowermost rays pure white. Caudal dusky with lighter margins, the lower lobe a little darker than the upper. Eye bright silver and blue-black.

I have to thank Mr. A. R. McCulloch for the privilege of using his fine plate of this species, which is taken from the publication noted at the head of this description.

Locality and Distribution.—Bay of Plenty, Auckland District, June, 1921; Port Hacking, New South Wales.

Cypselurus melanocercus Ogilby. Large Flying-fish. (Plate 22.)

Exocoetus melanocerus Ogilby, *Proc. Linn. Soc. N.S. Wales*, vol. 10, p. 123, 1885.

Br. 6; D. i/XIII; A. i/X; V. vi; P. xiv; C. xiv/$\frac{3}{3}$.

About 62 scales between the operculum and the middle caudal rays.

Depth before the ventrals $5\frac{3}{4}$ in the length to the hypural joint, head 5 in the same. Eye $3\frac{1}{2}$ in the head and equal to the length of the snout. Interorbital space $1\frac{1}{2}$ times the diameter of the eye.

Dorsal surface from the top of the operculum to within 30 mm. of the origin of the dorsal fin straight, flat. Ventral surface evenly curved from the chin to the caudal peduncle. The latter is long, narrow; its length subequal to the distance from the tip of snout to the centre of the operculum, and its median width subequal to that of the orbit. The whole body and head, with the exception of the tip of snout, top of preorbital, lips, and chin, covered with rather large highly deciduous cycloid scales, those on the sides of the head being extremely thin, and those from the dorsal fin to the caudal getting gradually smaller than those anterior to the dorsal fin. From the operculum to the origin of the dorsal the scales are nearly all of uniform size.

Lateral line very low on the sides, somewhat indistinct anteriorly, very pronounced behind the ventrals, and reaching to the lower caudal lobe.

Upper surface of the head broad, a little convex between the eyes. The snout curves downward slightly to the premaxillary. Nostril, a large single opening near the top of the snout, and situated much nearer the eye than the tip of snout. Eye large, placed near the top of the head. Preorbital broad, rather more than half the width of the eye. Maxillary very small, and completely hidden beneath the preorbital when the mouth is closed. Mandible very short, reaching backward as far as the middle of the preorbital. Teeth in the jaws minute, in villiform bands; none on the vomer,

palatine bones, or tongue. Preoperculum with its angle rounded and somewhat oblique. Operculum rounded, its margin very thin. Gills 4, a slit behind the fourth. Gill-rakers 16, on the lower half of the anterior limb. Dorsal fin with its origin well in advance of that of the anal, and somewhat elevated. Its first ray is longest, subequal with the height of the head at the operculum; the rest decrease in length gradually backward, the last ray being about $\frac{3}{4}$ the width of the eye.

The origin of the anal is the vertical from the third–fourth dorsal rays, but its last ray is almost below the last dorsal ray. Pectoral long, reaching backward as far as the base of the procurrent caudal rays, while its greatest width is subequal with the distance from the tip of the snout to its own base.

Origin of the ventral nearly below the centre of the pectoral. Its longest ray reaches backward as far as the tips of the third–fourth anal rays, while its greatest width is subequal with the base of the pectoral. Caudal strong, its lower lobe considerably longer than the upper.

Colour.—Dark steel-blue above, somewhat lighter on the sides, with the centres of the scales a little darker as far down as the middle of the height; below this it is silver-white as far as the lateral line, which is a trifle purer white in colour. Abdomen dirty-white. Cheeks and opercles from about the centre of the eye bright silver, with very pale golden reflections. Mandibulary region and lower jaw silver-white. Branchiostegal membrane white. Eye silver, with pale golden reflections and streaked bluish-grey on its outer margin, the lens being blue-black. Anterior pectoral rays light-coloured, the segmentations pale brown. The inner rays are pale brown, becoming much darker near their extremities and much lighter basally. There is a large white patch reaching across the fin almost mesially, but the position of this seems to vary somewhat in different individuals. The membrane of the pectoral varies in colour from slaty-blue at the base to almost black on its outer margin.

Dorsal fin dusky brown, the rays somewhat darker. Ventral with its central rays dusky brown, becoming lighter towards the margin; the membrane being dirty-white. Caudal brown, streaked darker.

Described from a specimen 365 mm. long from the tip of the snout to the hypural joint. Its greatest depth is 60 mm.; the length of the head 70 mm. Diameter of the eye, 18 mm.

Locality and Distribution.—Generally distributed throughout the Auckland east-coast district from the Bay of Plenty northwards. Plentiful at the entrance to the Hauraki Gulf and about the near outlying islands. Also recorded from the coast near Sydney, New South Wales, but considered rare.

Family HISTIOPTERIDAE.

Genus Paristiopterus Bleeker.

Paristiopterus labiosus. Giant Boar-fish. (Plate 23.)

Histiopterus labiosus Günther, *P.Z.S.*, p. 658, pl. 59, 1871. *H. farnelli* Waite, *Mem. Austr. Mus.*, No. 4, pt. 1, p. 116, pl. 27, 1899. *Paristiopterus labiosus* McCulloch, *Check List*, vol. 2, *Aust. Zoologist*, pt. 3, p. 92, pl. 28, fig. 239A, 1922.

D. viii/XVII; A. ii/XI; V. i/V; P. xvii; C. xvii/3+3; Br. 4.

Head 3 in the length to the hypural joint, and rather more than $1\frac{1}{2}$ in the height below the fourth dorsal spine. Eye $3\frac{1}{2}$ in the head, about as wide

as the interorbital space, and $1\frac{1}{2}$ in the snout. Gills 4, a slit behind the 4th ; 15 very short gill-rakers on the lower half of the anterior limb. Pseudobranchiae present.

Body deep, compressed, the dorsal profile forming an uneven curve, which is somewhat gibbous anteriorly in the region of the dorsal spines, and thence declivous to the caudal peduncle. The nape is sharp and rugose, and descends steeply to a prominence formed by a projection of the supraoccipital. Profile of the head concave between the eyes, convex above the snout. The ventral profile descends somewhat steeply from the chin to the origin of the ventrals, and thence straight to the anal. Caudal peduncle short, moderately broad, rounded above and below and compressed laterally ; its width is equal to $1\frac{1}{4}$ that of the eye.

The whole fish, with the exception of the top of the snout and interorbital space, is covered with small rugose scales (Plate 23, A) which cannot be distinguished from one another ; the fish appears as though covered with coarse-grained shagreen, which is somewhat finer on the opercular bones. Lateral line very indistinct ; commencing at the top of the scapula, it ascends obliquely to its highest point below the sixth and seventh dorsal spines ; it then descends gradually, and, passing across the middle of the peduncle, extends to the base of the caudal rays.

Mouth small, terminal, horizontal, the jaws equal when closed ; the extremities of the jaws are crowded with minute barbels, which are longest and most crowded on the mandible. Maxillary very small, its distal portion free, and reaching backwards as far as the hinder margin of the anterior nostril. Teeth villiform, obtuse, crowded anteriorily in both jaws, and forming a narrow band towards each angle. A few slightly longer and sharper ones are found at the apices of both jaws. None on the vomer, palatines, or tongue.

Snout smooth above, with a few detached spines on its lateral margins. Each nostril with a simple oval opening, which is placed subvertically on the snout in a line with the centre of the eye, and nearer to that organ than to the tip of snout. Interorbital space smooth. Above the anterior margin of each orbit is a prominence which is densely crowded with shor hard spines. Behind the eye curved extensions of the frontal bone spread upwards, and with their radii resemble outspread fans, which are separated mesially by a very narrow strip of rugose bone. Above the frontal the supraoccipital projects forward to the vertical of the centre of the orbit ; its edge is sharp and covered with hard flattened asperities. Preoperculum rugose, the margin strongly denticulated ; its angle is somewhat acute, and bears a cluster of spines. Operculum very finely rugose, covered with radii spreading downward and backward fanwise. Suprascapula very pronounced, reaching downward to the top of the operculum. Scapula largely exposed and covered with striae, as is the hinder margin of the coracoid.

Dorsal fin originating above the preoperculum, its spinous portion continuous with the soft, and depressible into a shallow groove. The first spine is equal to one-half the diameter of the eye, while the fifth is longest and equals the height of the body. All the spines are of irregular form, flattened and striated longitudinally. Dorsal rays slender ; the membrane is worn, and leaves a considerable portion of the rays free. Anal fin short, the length of its base equal to the distance between the anterior margin of the preorbital and the posterior margin of the eye. It is similar to the dorsal in character, its two spines and first and second rays being depressible in a groove, while those beyond are placed on a

slightly raised base. The first spine is equal to the first dorsal spine, and the second equals the length from the tip of snout to the anterior margin of the eye. Ventral very long, its origin beneath that of the pectoral. The longest ray reaches backward to the tip of the second anal spine when depressed. The length of the ventral spine nearly equals that of its longest ray; it is much flattened, rugose beneath and striated above like the dorsal spines. Length of the pectoral equal to the depth from the top of the orbit to the throat. Caudal subtruncate, its upper and lower lobes equal in length.

Colour.—Body yellowish-silver, somewhat deeper on the nape and above the anal fin. A black looped band, commencing at the base of the first and second dorsal spines, extends downward to the top of the operculum, and thence forward to the top of the supraoccipital. A second black band, commencing at the base of the fifth dorsal spine, extends vertically downward to the base of the pectoral, behind which it becomes very broad, and, following a lateral course along the lower half of the fish, embraces the basal quarter of the caudal peduncle and reaches the tail. A third band, commencing at the base of the sixth and seventh dorsal spines, is divided below the dorsal rays by a broad yellowish-silver streak; it becomes united again below the hinder margin of the fin, and again divided on the caudal peduncle: the upper surface of the latter is black, like the lower, while mesially the black band continues to the tail. There is also a small curved band, somewhat lighter in colour, originating at the base of pectoral, and, passing backward over the abdomen, reaches the first anal spine.

Cheeks blackish. Top of snout black. Frontal bones brown, with their radii bluish-grey. Premaxillary and mandible pink, the barbels at their apices dusky. Maxillary pale purple-pink, and covered with minute black dots. Throat pinkish-white. Operculum pale greenish-silver, the radii much lighter. Eye yellowish-silver and blue-black. Dorsal spines and rays plumbeus, the membrane black. Anal fin similar to the dorsal. Ventral spine light yellowish-silver, the rays and membrane similar to the dorsal. Pectoral blackish above, its lower rays being dull white. Caudal black, with its radii dull-greyish.

Described and figured from a young specimen, 140 mm. long to the hypural joint, which was trawled off Tauranga. Its greatest height is 70 mm., the length of the head 46 mm., the diameter of the eye 13 mm., and the depth of the caudal peduncle 16 mm.

Locality.—Not an uncommon species, and frequently trawled in good numbers from the Hauraki Gulf as far as the Bay of Plenty.

Family SCORPIDIDAE.

Genus Scorpis Cuvier and Valenciennes. (Plate 24.)

Definition.—Body compressed, oblong-ovate, the upper and lower profiles subequal, that above the eye convex. Body and greater part of the head covered with small ctenoid scales. Preoperculum serrated. Jaws with bands of teeth, and an outer more or less enlarged series. Minute teeth are also present on the vomer, palatines, pterygoids, and tongue. One dorsal with 9–10 spines increasing in length backwards, and 25 to 29 rays. Soft portions of the vertical fins with a scaly sheath. Pseudobranchiae and air-bladder present. Pyloric appendages in large numbers.

KEY TO THE NEW ZEALAND SPECIES.

A. Scales small, more than 100 above the lateral line between the head and the hypural joint. Eye moderately large. Maxillary about one-half the diameter of the eye. Interorbital space convex, but not markedly so. An equal number of rays in the dorsal and anal fins .. .. *aequipinnis.*

AA. Scales larger, about 89 above the lateral line between the head and the hypural joint. Eye smaller than in *S. aequipinnis.* Maxillary narrower. Interorbital space markedly convex. Anal rays less numerous than those of the dorsal .. .. .. *violaceus.*

Scorpis aequipinnis Richardson. Sweep.

Scorpis aequipinnis Richardson, *Ichth. "Erebus" and "Terror,"* p. 121, 1848: *id.*, Günther (part), *Brit. Mus. Cat. Fish*, vol. 2, pp. 64, 518, 1860, and *Ann. Mag. Nat. Hist.* (3), xx, p. 58, 1867. *Ditrema* var. (or sp.), Sandager, in *Trans. N.Z. Inst.*, vol. 20, p. 129, 1888. *Scorpis aequipinnis* Roughley, *Fishes of Australia and their Technology*, p. 141, pl. 45, 1916; McCulloch, *Rec. Aust. Mus.*, vol. 11, p. 177, fig. 2, 1916–17.

Br. 4; D. x/XXVII; A. iii/XXVII; V. i/V; P. xviii; C. xviii/$\frac{4}{4}$.

More than 100 series of scales above the lateral line between the head and the hypural joint; about 18 between the base of the first dorsal ray and the lateral line, and about 34 from the lateral line to the origin of the anal fin.

Depth before the ventrals $2\frac{1}{4}$ in the length to the hypural joint; head $3\frac{1}{4}$ in the same distance. Snout 4, eye $4\frac{1}{2}$ in the head. Interorbital space $1\frac{1}{4}$ the width of the eye. Caudal peduncle rather less than 3 in the head.

Body compressed, oblong-ovate, the upper and lower profiles subequal, that above the eye moderately convex. The entire body and head, with the exception of the lips and membranous parts about the mouth and nostrils, covered with small deciduous ctenoid scales. Scaly membrane covers the dorsal and anal rays, and the spinous portion of both fins has a scaly sheath at the base increasing in height backwards. Minute scales are also found on the base of the pectoral and caudal. Origin of the lateral line at the top of the operculum; it makes an even curve to below the anterior dorsal rays, then slopes gradually and reaches the caudal. Nostrils placed a little nearer the eye than the tip of snout, each with two simple oval openings, the anterior being largest and placed almost vertically on the snout. Mandible long, narrow, reaching to below the anterior $\frac{1}{4}$ of the eye.

Premaxillary teeth in dense villiform bands with an outer series which are longer and stronger; the bands cease abruptly about midway towards the angle of the mouth, the outer series continue to it, gradually getting smaller, those within the angle itself being minute. The mandibular teeth are similar to the premaxillary teeth, but both the bands and outer series extend to the angle. Preoperculum striate and finely serrated along its lower limb and round the angle, the vertical margin being somewhat irregular with no distinct serrations. Operculum elliptically notched on its upper posterior margin.

Gills 4; gill-rakers 28, on the lower half of the anterior limb.

Origin of the dorsal fin above the anterior quarter of the pectoral. The first spine is very short, one-third the diameter of the eye; those following increase in length backwards.

Origin of the anal fin is the vertical from the eighth to ninth dorsal spines; it is similar to the dorsal in form. The first spine one-half the width of the eye, and subequal with the ninth dorsal spine. The second anal spine is equal to the width of the eye, and subequal with the third dorsal spine. The first ray is $3\frac{1}{4}$ in the head, and rather more than twice as long as the last ray.

Origin of the pectoral near to the opercular margin; its length about 3 times that of the first dorsal ray, and reaching backward as far as the vertical from the eighth dorsal spine.

Ventral inserted a little behind the base of the pectoral, its spine subequal with the second anal spine.

Caudal forked, the upper and lower lobes about equal in length.

Colour.—Dorsal to just below the lateral line dark silvery-blue, lateral line somewhat darker; below lateral line greyish-silver, lightly sprinkled with a brassy or coppery tinge; abdominal region lighter. Dorsal fin a little lighter than the back; anal similar to the dorsal but a trifle lighter. Pectoral, ventral, and caudal uniform dark bluish-grey with the rays somewhat lighter. Eye silver and blue-black.

Described and figured from a specimen, 272 mm. long from the tip of snout to the hypural joint, trawled in the Hauraki Gulf, and often miscalled "maomao," which is the Maori name for *S. violaceus*, a fish much resembling *S. aequipinnis* excepting in colour and a few other specific differences which are shown in the key at the head of this description. It is common throughout the waters of the Auckland Provincial District. When on a visit to Whangaroa in March, 1914, I found the young of this species particularly abundant, swarming beneath the rocky headlands within the harbour. I do not agree with Sandager's remarks to the effect that it does not shoal, or feed upon the surface like *S. violaceus.* I have frequently observed huge shoals moving in a wide circle round some rocky island, or backwards and forwards past a headland, always swimming leisurely, many with their backs wholly exposed, undoubtedly feeding at or near to the surface.

Locality and Distribution.—Generally distributed throughout the Auckland Provincial District; South and south-western Australia.

Family POMACENTRIDAE.

Genus Chromis Cuvier.

Chromis dispilus n. sp. (Plate 25.)

The following key will serve to show the principal distinguishing characters between *Chromis dispilus* and its Australian congener:—

A. One white spot placed above the caudal peduncle immediately behind the dorsal fin. Snout obtuse, the profile markedly convex above the sye. Median dorsal spines shorter than the longest rays .. .. ***hypsilepis.***

AA. Two white spots, one below the tenth–eleventh dorsal spines, and the other below the posterior dorsal rays. Snout pointed, the profile not markedly convex above the eye. Median dorsal spines as long as the longest dorsal rays .. ***dispilus*** **n. sp.**

Br. 4; D. xiii/XIV; A. ii/XIV; V. i/V; P. i/XX; C. xvi/$\frac{8}{8}$.

About 27 scales between the head and the hypural joint, the transverse series being 4 above and 10 below the lateral line.

Height of body rather less than 2 in the length to the hypural joint, the head is 3½ in the same distance. Eye 3 in the head, and slightly wider than the interorbital space. Snout ¾ the width of the eye. Caudal peduncle 2 in the head.

Body deep, compressed, the dorsal profile more elevated than the ventral, and rising somewhat steeply from the snout to the anterior dorsal spine, thence curving evenly to the caudal peduncle. The entire body and head, with the exception of the tip of the snout, chin, lips, and maxillary bones, covered with ciliated scales, those on top of the head, cheeks, and sub-operculum being much smaller than those of the operculum and body. Small scales are also found extending more than half-way up the vertical fins between the spines and rays, and similar ones furnish the sides of the tail and base of the pectoral fin. There is also a large pointed scale at the base of the ventral. Lateral line rather high, curved, and terminating below the median dorsal rays. A second but less distinct series of tubes runs along the middle of the caudal peduncle, covering about 8 or 9 scales. Mouth small, oblique, the maxillary reaching almost as far as the first quarter of the eye. Teeth conical, acute, spaced, arranged in a band in front, gradually changing into a single series on the sides, the anterior teeth in both jaws being slightly the longest. Nostril round, placed nearer to the eye than the tip of snout. Preorbital narrow, about one-third the width of the eye. Interorbital space moderately convex. Margin of the pre-operculum smooth, its angle rounded. Operculum ending in a single flat spine. Gills 3½; gill-rakers 24, on the lower half of the anterior limb. Pseudobranchiae present. Origin of the dorsal fin is the vertical from the tip of the opercular spine. Its first spine is short, three-fourths as long as the eye, the fifth and sixth the longest, rather more than half the length of the head, while those following decrease in length gradually backward, the last being equal to the second. The rays are rounded above, and somewhat elevated, the sixth and seventh subequal and longest, equal to the median dorsal spines. The origin of the anal is the vertical from the ninth dorsal spine, its length equal to the distance from the first to the ninth dorsal spines, the median rays are as long as the median dorsal rays. The first spine is short, equal to the first dorsal spine, the second strong, and equal in length to the fourth dorsal spine. Pectoral pointed, reaching backward to below the eleventh or twelfth dorsal spines, while its length is 2½ in the total to the hypural joint. Ventral inserted a little behind the base of the pectoral, reaching backward as far as the first anal spine. Caudal forked, the upper lobe being the longest.

Colour.—Top of head and dorsal above the lateral line blackish-green, lateral line somewhat deeper. Below greenish-silver, the centres of all the scales reflecting ultramarine-blue. Behind the head and above the base of the anal fin there is a purple hue overlying the ground-colour. A white spot placed just above the lateral line below the tenth–eleventh dorsal spines, and a second white spot situated below the posterior dorsal rays. Eye golden-yellow and blue-black. Cheeks and opercles same as the body-colour below the lateral line. Opercular spine pale yellowish-white. Maxillary and lower jaw pinkish-white. Spinous dorsal dusky purple, the spines much lighter; the rays are of the same ground-colour, but there is a median band of black passing through them. Anal fine like the dorsal. Pectoral dusky pink, the rays lighter, and a large black patch at its base partly on the fin and partly on the body.

Described and figured from the holotype, a female, 157 mm. long from the tip of snout to the hypural joint, which was trawled on the west coast of the North Island of New Zealand in June, 1921. Its greatest height is 88 mm., the length of the head is 43 mm., diameter of the eye 17 mm., and the depth of the caudal peduncle 24 mm.

Variation.—Three specimens were trawled about the same time, two of which were females, with the third a male, the latter being much narrower in body than the females; apart from this they appeared identical in every other way.

Affinities.—This species is very similar to *Chromis hypsilepis*, recorded from Lord Howe Island, and the coast of Australia near Sydney, and described and figured by Mr. A. R. McCulloch in *Zool. Res.* "*Endeavour*," pt. i, p. 73, pl. xiv, 1911. In submitting a specimen of our species to him for comparison with *C. hypsilepis*, he writes as follows: "I have carefully compared your specimen with several of *C. hypsilepis*, and am satisfied it represents a distinct species. Apart from the colour-marking, the differences between the two are comparative, and cannot be expressed in definite terms."

Locality.—Trawled off Reef Point, a little to the south of Ahipara Bay, North Auckland district.*

Family ZEIDAE.

Genus Zenopsis Gill.

Zenopsis nebulosus Schlegel. Mirror-dory. (Plate 26.)

> *Zeus nebulosus* Schlegel, *Faun. Japon.*, *Pisces*, p. 123, pl. 66, 1847.
> *Zenopsis nebulosa* McCulloch, *Zool. Res.* "*Endeavour*," vol. 1, pt. 1, p. 83, pl. 16, fig. 1, 1911.

During the months of June and July a number of specimens of the mirror-dory were trawled by the s.s. "James Cosgrove" between White Island, in the Bay of Plenty, and the entrance to the Hauraki Gulf, Auckland, this being, I believe, the first time the species has been recognized from our waters. The most noticeable difference between this fish and the common john-dory (*Zeus faber*) lies in the remarkable mirror-like appearance of the scaleless body of the former, while it has three only instead of four anal spines. That it has not often been seen in the Auckland markets is doubtless due to the fact that it is a deep-sea species, and our trawling operations seldom extend to the deep waters it inhabits. From recent observations I feel confident it is fairly plentiful with us, and should become an important addition to our list of prized table fish.

Locality.—From Hauraki Gulf to White Island, in the Bay of Plenty. McCulloch records it from off Cape Everard, Victoria, in 70 fathoms, and from twenty miles north-east of Babel Island, Bass Strait, in 68 fathoms, and Disaster Bay, New South Wales, in 45 fathoms.

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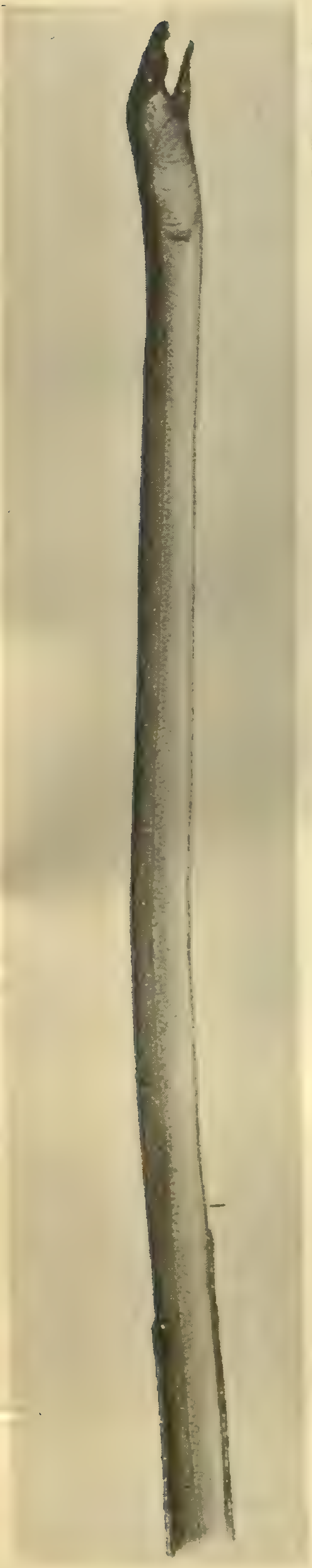
* Since the above description and figure were prepared I have received five other fine specimens, caught at the Mokohinau Islands by Mr. Shirley, a local fisherman, who reports that it is not an uncommon species in that neighbourhood, but difficult to catch with hook and line.



[L. T. Griffin, del.

FIG. 1.—*Muraenichthys australis* Macleay. × $\frac{4}{5}$.

[L. T. Griffin, del.

FIG. 2.—*Chimaera novae-zealandiae* Fowler. Mature male. × $\frac{2}{3}$.

Face p. 256.]

[A. R. McCulloch, del.

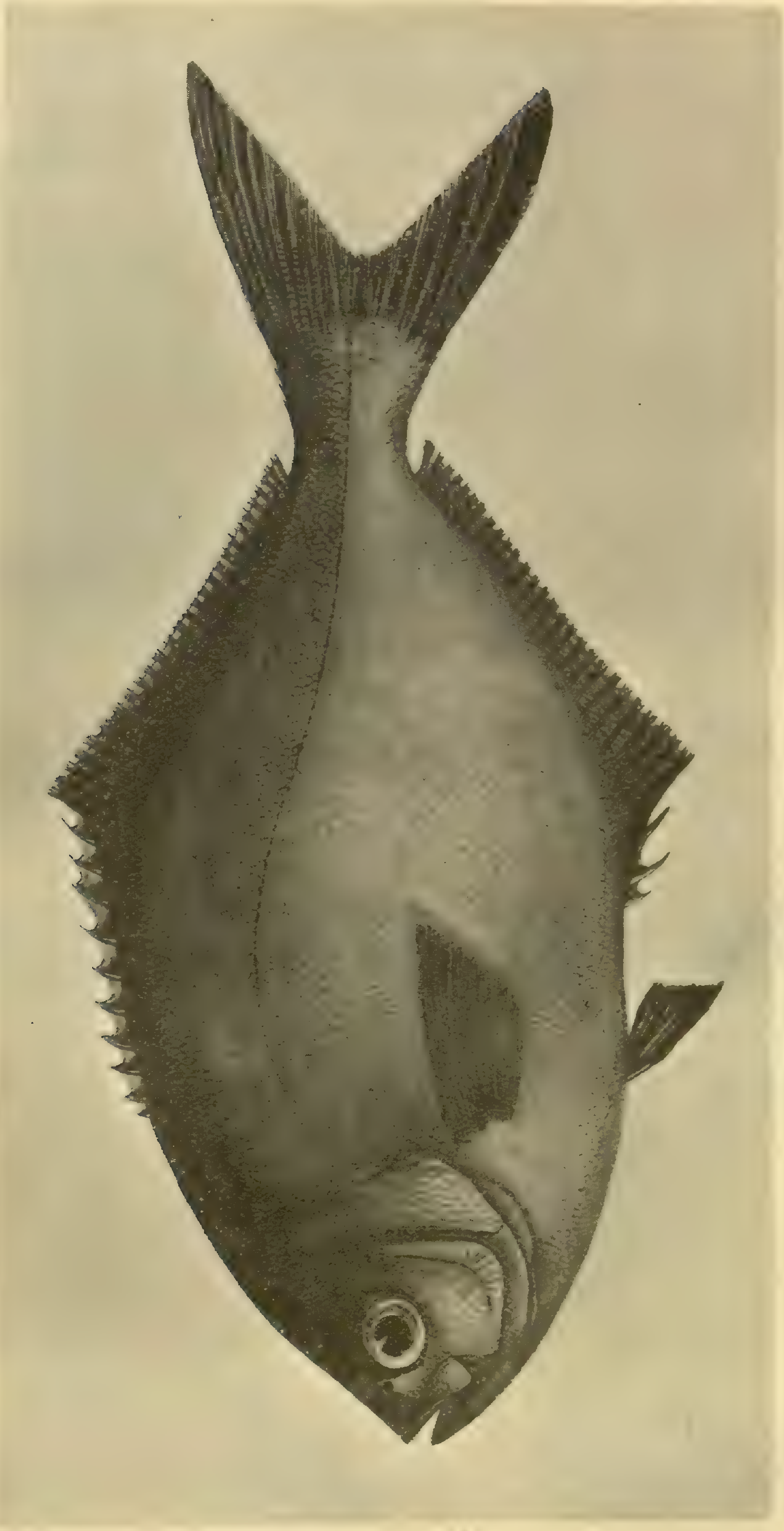
Cypselurus cribrosus Kner. $\times \frac{2}{3}$.

L. T. Griffin, del.

Cypselurus melanocercus Ogilby. $\times \frac{2}{3}$.

[L. T. Griffin, del.

Paristiopterus labiosus. Male. × $\frac{3}{5}$.
A, scale from the side of *Paristiopsis labiosus.* × 18.



[L. T. Griffin, del.

Scorpis aequipinnis Richardson. (Sweep.) × ½.

[L. T. Griffin, del.

Chromis dispilus n. sp. × $\frac{4}{5}$.

Zenopsis nebulosus Schlegel. (Mirror-dory.) $\times 1\frac{1}{3}$.

[*L. T. Griffin, del.*

ART. 24.—*Two Species of Delphacidae (Homoptera) from Kermadec Archipelago.*

By F. MUIR, Hawaiian Sugar-planters' Experiment Station, Honolulu, T.H.

Communicated by J. G. Myers.

[*Read before the Wellington Philosophical Society, 31st August, 1921; received by Editor, 31st December, 1921; issued separately, 30th April, 1923.*]

Sardia rostrata Mel.

Hadeodelphax pluto Kirkaldy, *H.S.P.A. Expt. Sta. Bull. 1*, p. 410, 1906.

One male and one female from Raoul Island (Sunday Island), Kermadec Archipelago.

Hitherto I have kept *rostrata* and *pluto* apart, but the variation in colour-difference and even in the length of the head is not specific. The species has a wide distribution in the Pacific—Samoa, Fiji, eastern Australia, Philippines, Borneo, Java, Penang, India, and Ceylon.

Micromasoria raouli n. sp.

♂. Brachypterous; length, 4·6 mm.; tegmen, 1·7 mm. Tegmina reaching posterior margin of fourth abdominal tergite. In structure close to *M. caelata* (White), basal segment of antenna slightly flattened and face slightly broader; the five mesonotal carinae distinct; hind tibiae with four spines.

Clay-colour or tawny olive; face speckled with lighter dots; middle and front legs banded with darker-brown bands, clypeus dark brown, some darker marks on abdomen. Tegmina with a dark mark at apex between cubitus and suture and a small dark mark on Sc+R near base.

Medio-ventral edge of pygofer roundly produced; anal emargination large, anal angles obscure, not produced; anal segment large, filling up greater part of opening of pygofer and hiding aedeagus, lateral margins curved round ventrad and meeting together at apex; genital styles subawl shape, slightly curved.

♀. Brachypterous; length, 5·4 mm.; tegmen, 2·4 mm. In colour similar to male. Ovipositor curved, projecting slightly beyond apex of abdomen.

In a full-grown male nymph the antennae are comparatively slightly shorter and thicker.

Described from one male, one female, and a nymph from Raoul Island (Sunday Island), Kermadec Archipelago. The species is named after the officer who first sighted the island and after whom the latter is named. Types in Dominion Museum, Wellington.

The genus *Micromasoria* is closely allied to *Ugyops*, and it will be difficult to keep the two separated.

These specimens were all from the W. R. B. Oliver expedition to the Kermadecs in 1908, and were collected by Mr. W. L. Wallace.

ART. 25.—*New Species of New Zealand Delphacidae (Homoptera).*

By F. MUIR, Hawaiian Sugar-planters' Experiment Station, Honolulu, T.H.

Communicated by J. G. Myers.

[*Read before the Wellington Philosophical Society, 2nd August, 1921; received by Editor, 31st December, 1921; issued separately, 30th April, 1923.*]

Nilaparvata myersi n. sp. (Figs. 1, 1A.)

♂. Macropterous; length, 2·6 mm.; tegmen, 3·3 mm. Head nearly as wide as thorax; length of vertex subequal to width, apex slightly narrower than base, projecting beyond eyes, median carina projecting prominently, base considerably behind middle of eyes; length of face 2·3 times width, sides subparallel, base slightly narrower than apex, median carina simple. Antennae reaching slightly beyond base of clypeus, second segment 1·5 times length of first. Lateral pronotal carinae diverging, curved, not reaching hind-margin. Hind basitarsus as long as or slightly longer than the other two together; spur large, as long as basitarsus, broad, laminate, concave on inner surface, numerous (fifteen to twenty) distinct teeth on hind-margin.

Opening of pygofer wider than long; lateral margins not continuous with ventral, rounded, entire, ventral margin ending in a slight elevation beside foramen of diaphragm; anal emargination wide, shallow, anal angle rounded, slightly produced. Diaphragm long, dorsal margin steeply sloping at sides, middle portion sinuate, asymmetrical and slightly projecting in middle. Anal segment median size, short, with two strong, laterally-flattened and curved spines with their bases not touching. Genital styles large, flat, broad, basal angle large, beyond which inner margin concave, outer margin sinuous, apex truncate, straight, broad, inner angle projecting, rounded at apex and turned at an angle to main body. Aedeagus comparatively small, basal half subcylindrical, slightly flattened laterally; apically pointed, with a row of about five teeth along right side and three minute ones more dorsad, on ventral aspect produced into a thick, curved spine. Orifice not detected; it may be on curved spine or on main body.

Black or dark brown, legs lighter, base of abdomen yellowish. Tegmina hyaline, dark mark on hind-margin from middle of clavus to apex of claval vein; fuscous over greater part of clavus, less so over cubital area and around apical margin. Veins slightly darker than membrane, granules minute, sparse, black. Wings hyaline, veins brown.

Described from one male from Mount Alpha, Tararua Range, Wellington, North Island, 4,500 ft. elevation. (*J. G. Myers*, 15th February, 1921, No. 158). Type in Dominion Museum, Wellington.

This is quite a distinct species, the aedeagus being unlike any I am acquainted with.

Delphacodes tasmani n. sp. (Figs. 2, 2A.)

♂. Macropterous; length, 2 mm.; tegmen, 2·7 mm. Length of vertex equal to width at base, vertex projecting beyond eyes, median carina projecting, base slightly behind middle of eyes, slightly wider than apex. Length of face 2·2 times width, sides subparallel, median carina simple. Antennae reaching slightly beyond base of clypeus, second segment 1·7 times the

length of first. Pronotal carinae curved, diverging, not reaching hind-margin. Hind basitarsus slightly longer than other two together; spur as long as basitarsus, broad, laminate, about twenty small black teeth on hind-margin.

Opening of pygofer wider than long, lateral margins entire, round, slight emargination on ventral margin, anal emargination shallow, broad, anal angles obscure, not produced. Diaphragm fairly long, dorsal margin widely U-shaped with middle straight and very slightly projecting, no distinct armature. Anal segment large, spine short, broad, laterally flattened, curved, bases wide apart and diverging to apex; a second pair of spines at base of anal segment on ventral side, laterally flattened, apices acute. Genital styles flat, fairly narrow, inner margin slightly concave on apical third, convex basally, outer margin slightly sinuous, apex truncate, outer angle fairly acute, inner angle rounded. Aedeagus long, subtubular, slightly flattened laterally, in lateral view slightly largest on basal half, orifice at apex on left side, a row of seven or eight teeth from dorsal aspect of apex along each side to a ventral point about middle; one or two small teeth apical to this on ventral aspect.

FIG. 1.—Anal segment and aedeagus of *Nilaparvata myersi.*
FIG. 1A.—Left genital style of same.
FIG. 2.—Anal segment and aedeagus of *Delphacodes tasmani.*
FIG. 2A.—Left genital style of same.

Light brown; darker between carinae of face, clypeus and genae, and on pleura of thorax; legs lighter brown, abdomen dark. Median carinae of thorax and the base of commissure light. Tegmina hyaline, a small dark mark on hind-margin at apex of claval vein, veins slightly darker than membrane, apical veins darker, granules minute, sparse, dark, bearing small black macrotrichia.

♀. Macropterous; length, 2·5 mm.; tegmen, 3 mm. Slightly darker than male.

Described from one male (holotype) and one female (allotype) from Waikanae (*J. G. Myers*, 4th February, 1921. No. 125). There is a second female (paratype) from Bull Mound, Tararua Range, 3,300 ft. elevation (*J. G. Myers*, 13th February, 1921). Another female from Waikanae may be immature; it is very much lighter in colour. All these deposited in the Dominion Museum, Wellington.

Beside the above two species, one other species of *Delphacodes* is known from New Zealand (*D. meridianalis* Muir*), which is closely related to *D. tasmani*. If they should prove to be the same species it will be of interest, as it will show a distinct difference of genitalia in the brachypterous and macropterous forms.

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* *Proc. Hav. Ent. Soc.*, iii, 4 (1917), p. 334, pl. v, figs. 24, 24A.

Art. 26.—*Notes on the Blepharoceridae (Diptera) of New Zealand.*

By J. W. Campbell.

[*Read before the Philosophical Institute of Canterbury, 2nd November, 1921; received by Editor, 31st December, 1921; issued separately, 30th April, 1923.*]

Unexpected circumstances prohibit more than a fragmentary continuance of the notes published in the writer's previous paper,* where there were figured three forms of larvae, assumed to be identical with Bezzi's larvae, and, following his papers,† they were designated larva A, B, and C. A study of the larval stages of *Curupira chiltoni* Campb. shows conclusively that larva C is a young stage of larva A (*C. chiltoni* Campb.), and not the larva of *Peritheates turrifer* Lamb, as was suggested. There is no evidence for the presence of any species other than *C. chiltoni* Campb. in the Banks Peninsula creeks searched by the writer, and it seems probable that *C. chiltoni* alone inhabits the whole of those creeks, where it will be remembered the larvae A, B, C of Bezzi were secured. Professor Bezzi's description of his larva C fits no larva known to the writer except the so-called larva C of Purau Creek (Lyttelton Harbour), and this is the only known larva with the subquadrate yellow spot in the middle of the dorsum of the fourth segment.‡ In their development the larvae of *chiltoni*, after completion of the colour-pattern, develop subdermally the large black spines of a third form of armature, and at the next moult emerge with the characteristic black spines of the species (see figs. 1–9). From evidence in the writer's possession it seems certain that larvae of the *chiltoni* type alone have the three distinct forms of armature (*i.e.*, V-shaped, cone, and long black spines) during development, the other New Zealand species, of the *hudsoni* or *harrisi* or the Queenstown types, having but two forms, the second consisting of the transparent cone spines referred to in the writer's previous paper* (figs. 22–27). Further communication with

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* J. W. Campbell, *Trans. N.Z. Inst.*, vol. 53, pp. 258–88, 1921.

† M. Bezzi, *Bull. Soc. Ent. Ital.*, vol. 44, pp. 1–113, 1913; vol. 45, pp. 115–29, 1914.

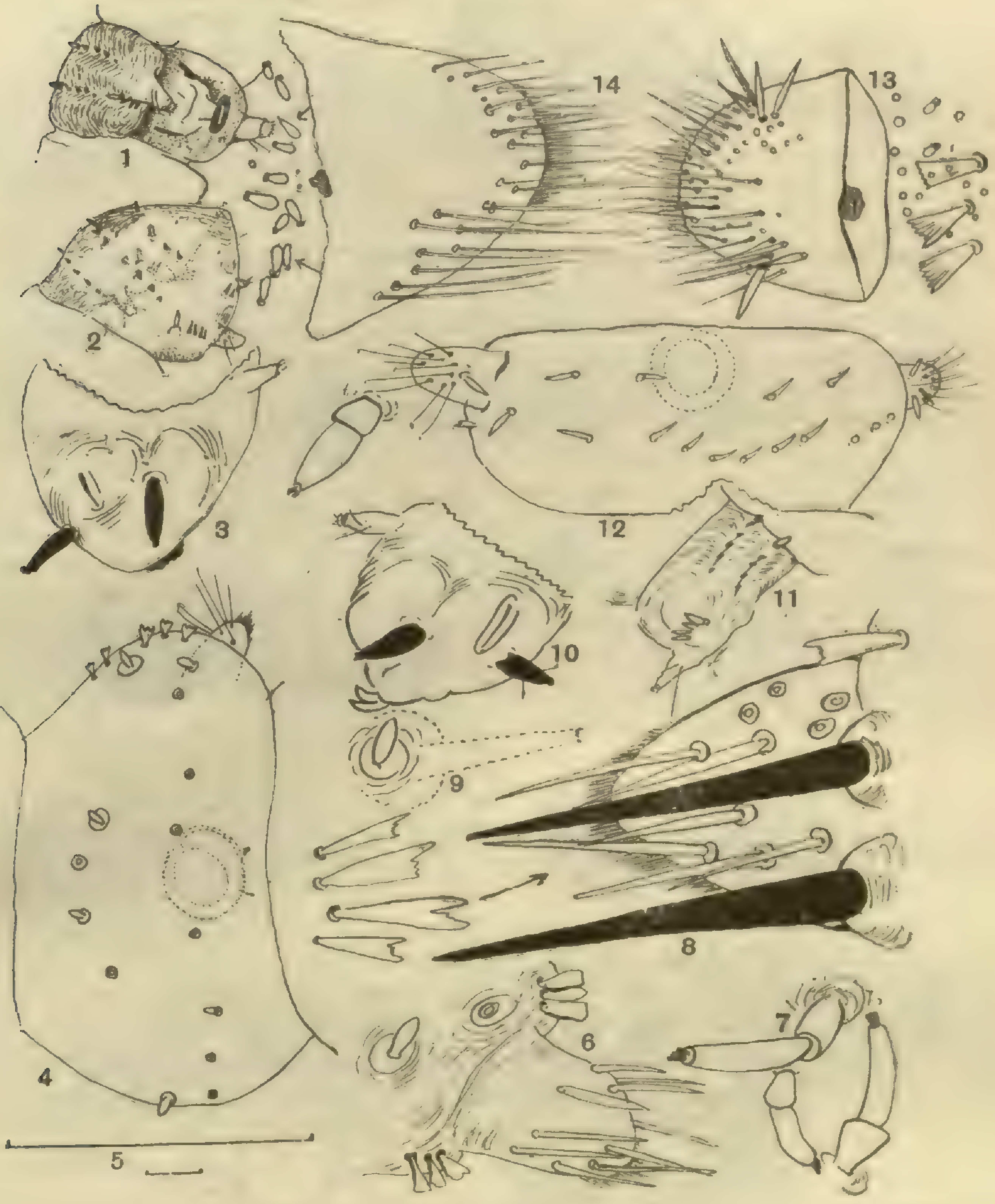
‡ The following table is added to make the position clear:—

1921.

Larva. (Bezzi, 1913–14.)		Fig. (Campbell, 1921.)
A (assumed to be *N. hudsoni*)	..	A = *C. chiltoni* Campb.
B (unrelated)	..	B = *N. hudsoni* Lamb.
C (probably *P. turrifer* Lamb)	..	C (possibly *P. turrifer* Lamb).

1922.

Larva.		Fig.
A = *C. chiltoni* Campb.	..	A = *C. chiltoni* Campb.
B = *C. chiltoni* Campb., young stage	..	B = *N. hudsoni* Lamb.
C = *C. chiltoni* Campb., young stage	..	C = *C. chiltoni* Campb., young stage.



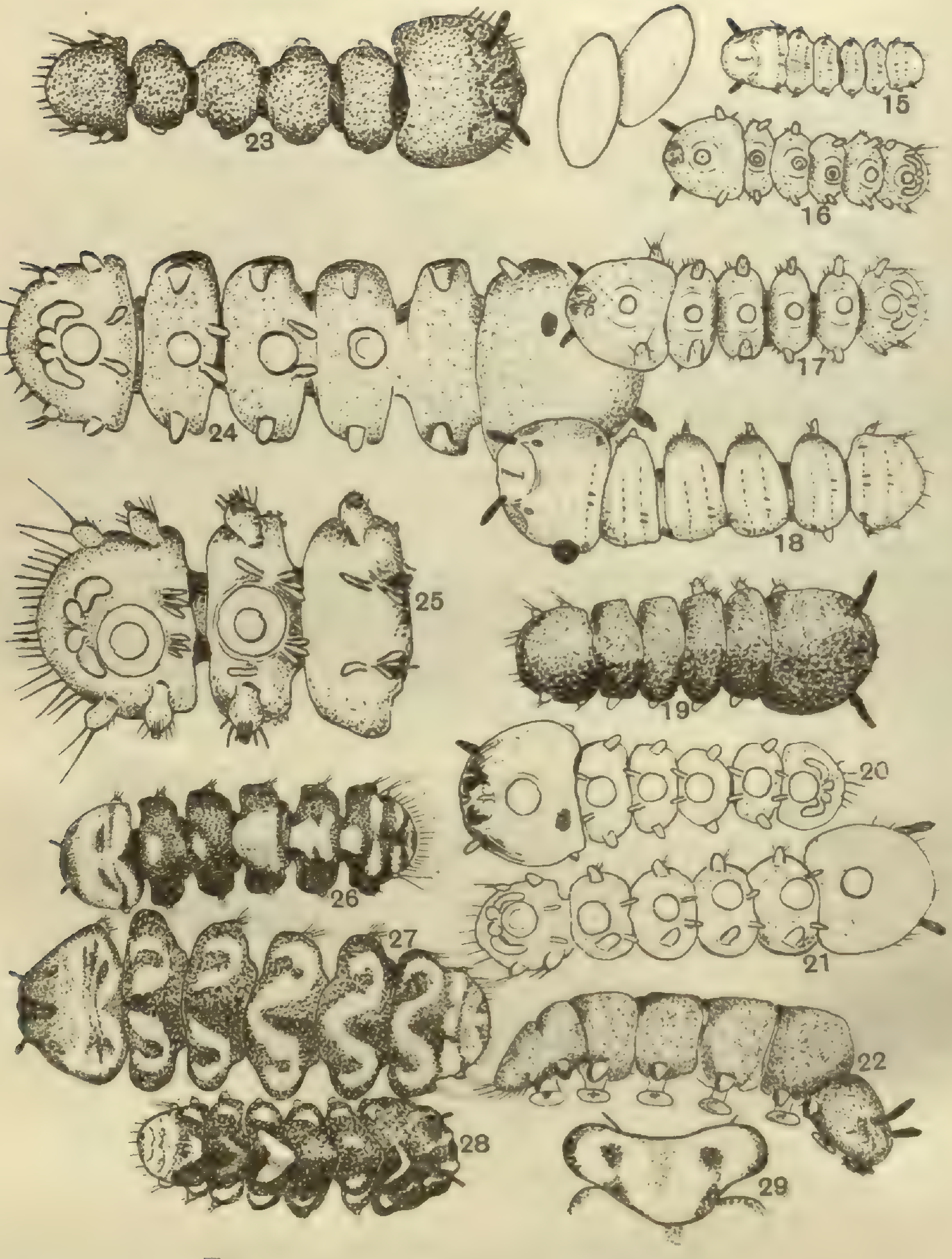
FIGS. 1–9.—*Paracurupira chiltoni* Campb.

1. Abdominal segment, first instar.
2. Sixth segment, first instar.
3. Cephalothorax, first instar.
4. Abdominal segment, showing second armature.
5. Relative increase of diameter of disc.
6. Lateral process and second armature.
7. Increases of size of antenna (four stages).
8. Lateral process (tip), third armature.
9. Position of spines in transition stage.

FIGS. 10–13.—*Peritheates harrisi* Campb.

10. Head, first instar.
11. Abdominal segment, first instar.
12. Abdominal segment, showing second armature.
13. Lateral process (mixed spines).

FIG. 14.—Queenstown larva, lateral process. Gills, 7 in. tuft anterior margin segments. Armature and first instar similar to *harrisi*. Male imago larger than *chiltoni*; venation similar. Eyes bisected, dichoptic.



FIGS. 15–26.—*Paracurupira chiltoni* Campb.

15–18. Ova and four sizes of larva with the first-stage armature. No increase in size of disc. First instar ?

19–24. Five sizes of larva, with additional one gill aside. Disc approximately doubles in diameter. Sixth segment marginal spines increase to 6 or 7. Armature, 12, 14, 18 cone spines.

25. Four gills. Lateral process assumes club form. Marginal spines 18–20. Colour-pattern commences with subquadrate yellow spot. Disc again doubles in diameter.

26. Completed pattern.

FIGS. 27–29.—Queenstown larvae.

27. Adult larva.

28. Young, with pattern developing.

29. Abdominal segment, extreme form.

The average larva has the broad V separated from the lateral lunar marks

Professor Bezzi inclines the writer to believe that his larva B* (pp. 122–123) is also a stage of larva A, and it is not surprising that in the specimens collected by Dr. Chilton there should have been three distinct stages of larva A taken from the stream at Akaroa. The larva of *chiltoni* (see figs. 15–26) in its first instar can be distinguished by its one-jointed antenna, and has the anal set of gills only. The cephalothorax is nearly destitute of spines or setae, and on the dorsum the main armature consists of 12 spines, in rows of 2 and 10 respectively. On the abdominal segments are two rows of 10 spines in each row. Laterally near the pseudopods are groups of 4 spines. On the sixth segment there are three rows of 12, 14, and 6 spines, with lateral groups of 4 spines near the processes. In each segment one spine of each lateral group is larger and cone-shaped, as are the innermost spines of each half-row, the remainder being wedge- or V-shaped. These 6 larger spines are visible in each segment when the young larva is viewed through the membrane of the egg just before emergence. A moult occurs, and the larva emerges in its second instar with normal two-jointed antennae and increase of setae and spines. The larva is characterized by complete loss of the whole series of small black spines. The armature consists of transparent cone spines, 12 on the cephalothorax, 14 on the abdominal, and 18 on the sixth segment (1921†, figs. 22–27). An increase of one gill a side occurs on all segments except the first (see figs. 19–24), and from this stage they appear to increase in number irrespective of the moults. After the second ecdysis the larvae are still of the uniform dark-brown or "black" colour, and well-developed specimens are characterized by the appearance of the subquadrate yellow spot on the middle of the dorsum of the fourth segment. This coloration extends to the other segments till the pattern is completed. The black large spines of the fourth instar are visible through the epiderm of the third, and both cone spines and large black spines are clearly visible in a slide preparation. The freshly emerged larva of the fourth instar is characterized by the bright-yellow colour of the tubercles of the large erect black spines, giving the larva a spotted appearance. The lateral processes gradually change in shape from a cone to a club-shaped structure, and the club shape is a definite character after the transition from cone spine to black-spine armature.

The table on p. 264 is temporary, and subject to correction.

The writer wishes to express his keen appreciation of the help and encouragement he has invariably received from Professor Bezzi, and his indebtedness to Messrs. Myers and Hamilton, and many friends, for specimens and new species. Investigation of the immature stages has only been possible through the very determined and disinterested efforts of Messrs. W. G. Howes, Leon Curtis, and T. R. Harris to secure from their various localities a series ranging from the egg to the mature larva and pupa.

Dr. R. J. Tillyard's revision of these interesting flies will be found in the *N.Z. Journal of Science and Technology*, vol. 5, pp. 101–7, 1922; and students will look forward with interest to the work of Monsieur E. Tonnoir, of the Brussels University, now at the Cawthron Institute, Nelson, who is at present engaged in a study of the whole Australasian group of Blepharoceridae.

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* M. BEZZI, *Bull. Soc. Ent. Ital.*, vol. 45, pp. 115–29, 1914.
† J. W. CAMPBELL, *Trans. N.Z. Inst.*, vol. 53, p. 270.

Table of Larvae.

Species.	Instars.	Gills.*	Antenna Joints.	Primary Spines.				Lateral Processes.	
				Cephalothorax.	Abdominal.	Sixth Division	Lateral Groups.	Characters.	Shape.
Paracurupira chiltoni Campb.	1st	4A	1	2, 4, cone; 4, 4, wedge	2, 4, cone; 8, 8, wedge	4, 4, 2, cone; 8, 10, 6, wedge	4	Spines strong, stout, 2–3	Cone.
	2nd	+1	2	12 cone ..	14 cone ..	4, 8, 6, cone ..	..	Spines increase, 6–8 ..	Cone.
	4th+	2–7	2	12, long black ..	14, long black ..	18, long black ..	..	Spines increase, 25+	Club.
Peritheates harrisi Campb.	1st	4A	1	2, 4, cone; 8, wedge	2, 4, cone; 8, 8, wedge	4, 4, 2, cone; 8, 10, 6, wedge	4	Spines stout, 2 ..	Cone.
	2nd	+1	2	4, 8, sharp-point cone	12, 4, sharp-point cone	6, 8, 6, sharp-point cone	..	Spines stout, 3; fine, 5–6	Cone.
	4th+	2–7	2	12, sharp-point cone	14, sharp-point cone	20 sharp-point cone	..	Spines mixed, 25–30 ..	Cone.
Neocurupira hudsoni Lamb	..	Young stages not known.			Primary armature present (not determined)		..	Spines long, fine, 30 ?	Cone.
Peritheates turrifer Lamb	..	..	..	Not known ..	..	..	..	..	Cone ?
Peritheates n. sp. Tillyard	..	..	..	Not known.					
Peritheates n. sp. Campb. / *Peritheates* n. sp. 2 Campb. (Wellington, Kaitoke)	..	..	..	..	4, 8, cone ? ..	12, 4, cone ..	6, 8, 6, cone	Spines stout and fine, mixed	Cone.
Paracurupira n. sp. Campb.	1st	4A	1	2, 4, cone; 4, 4, wedge	2, 4, cone; 8, 8, wedge	4, 4, 2, cone; 8, 10, 8, wedge	4	Spines fine, 2 ..	Cone.
Queenstown	2nd	+1	2	4, 8, cone ? ..	16 ? cone ..	20 ? cone ..	..	Spines fine, 8–10 ..	Cone.
Waipori	4th+	2–7	2	12 ? cone ..	16 ? cone ..	20 ? cone ..	..	Spines fine, 25–30; not so long and fine as in *hudsoni*	Cone.
Paracurupira n. sp. Tonnoir	..	..	..	Larvae and pupae collected ..		..	..	Ditto	Cone.
West Coast	..	..	..	Probably identical with Queenstown form.					

* A = anal gills only.

NOTE.—The number and position of these armatures is probably the same for all species, the slight difference being due to the fusions in the first and sixth divisions. Indications of a greater number than the average 12, 14, 18 are present in the reduced areas.

ART. 27.—*A Preliminary Revision of the Crane-flies of New Zealand (Anisopodidae, Tanyderidae, Tipulidae).*

By F. W. EDWARDS, B.A., F.E.S.

Communicated by G. V. Hudson, F.E.S., F.N.Z.Inst.

[*Read before the Wellington Philosophical Society, 26th October, 1921; received by Editor, 31st October, 1921; issued separately, 30th April, 1923.*]

(Published by permission of the Trustees of the British Museum.)

Plates 27–36.

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INTRODUCTION.

IT is hoped to make this paper the first of a series dealing with the Nematocerous Diptera of New Zealand. The three families treated in this contribution are not particularly closely related, but are treated together because they all (except perhaps the genus *Anisopus*) come under the heading of crane-flies.

KEY TO THE FAMILIES OF NEMATOCERA.

In the following key an attempt has been made to utilize several recent suggestions as to relationships of the families of Nematocera; but to produce a workable key which, while not burdened with exceptions and qualifications, will yet group the families in a natural manner is no easy task. This one will perhaps be useful for the time being, until a more satisfactory one can be framed. The least satisfactory character used is that of the ocelli. Although these are absent in the Cecidomyiinae and present in the Anisopodidae, the first of these groups is certainly nearly allied to the Mycetophilid series, which possess ocelli, and the second to the Tipulid-Culicid series, which have no ocelli. The Simuliidae, again, though without ocelli, show many points of resemblance to the Blepharoceridae (*e.g.*, in having wings folded and bent over in the pupa, a remarkable feature which is found only in these two families, and probably in the recently discovered Deuterophlebiidae). Wingless forms are inevitably excluded from the key.

1.	Wings with a network or fanlike arrangement of creases, due to the folding of the wing in the pupa	2
	Wings without such creases, contracted but not folded over in the pupa (except in Simuliidae)	3
2.	Ocelli, mouth-parts, and true venation absent	DEUTEROPHLEBIIDAE.
	Ocelli, mouth-parts, and true venation present	BLEPHAROCERIDAE.
3.	Venation very much reduced, the media entirely lacking	CECIDOMYIIDAE.
	Venation less reduced, at least one branch of the media remaining	4
4.	Ocelli present	5
	Ocelli absent	13
5.	Radial sector forking far beyond the radio-median cross-vein, or not at all	6
	Radial sector forking close to or before the radio-median cross-vein (as in the Tipulid series)	11
6.	Antennae placed close to the oral margin, below the compound eyes	BIBIONIDAE.
	Antennae placed far from the oral margin, at or above the middle of the compound eyes	7
7.	Tibiae without distinct spurs; thorax without well-marked bristles differentiated from the pubescence	8
	Tibial spurs well developed; thorax nearly always with distinct even if small bristles	9
8.	Very bare flies, the supra-antennal portion of the eyes broad	SCATOPSIDAE.
	Very pubescent flies, the eyes connected above the antennae by a narrow bridge only (CECIDOMYIIDAE, subfam.)	LESTREMIINAE.
9.	Anterior branch of radial sector little if any shorter than the long sector itself (? MYCETOPHILIDAE, subfam.)	DITOMYIINAE.
	Anterior branch of radial sector short or absent (when distally placed it is less than half as long as the sector; in some genera it is retracted towards the base of the sector, but is then very short)	10
10.	Coxae moderate; eyes nearly always connected above antennae by a narrow bridge	SCIARIDAE.
	Coxae elongate; eyes generally widely separate and at most slightly emarginate	MYCETOPHILIDAE.
11.	Second anal (axillary) vein reaching the wing-margin; mesonotum with a well-marked suture (? ANISOPODIDAE, subfam.)	TRICHOCERINAE.
	Second anal vein not reaching the wing-margin; mesonotal suture not developed	12
12.	Lower branch of cubitus more or less concave above	ANISOPODIDAE.
	Lower branch of cubitus convex above (? MYCETOPHILIDAE, subfam.)	PACHYNEURINAE.
13.	Two anal veins distinctly reaching the wing-margin; mesonotum with complete V-shaped suture	TIPULIDAE.
	At most one anal vein reaching the wing-margin; mesonotal suture generally indistinct or absent	14
14.	First antennal segment well developed, generally longer than the second, which is not conspicuously enlarged	15
	First antennal segment reduced to a narrow ring or absent, the second much enlarged	18
15.	Wings very broad, the venation much reduced, media and cubitus fainter than the radius	SIMULIIDAE.
	Wings with the venation less reduced, all veins equally strong	16
16.	Anal vein very short or absent; small, densely hairy flies	PSYCHODIDAE.
	Anal vein long, reaching to middle of wing or nearly; large, comparatively bare, long-legged flies	17
17.	Radius five-branched, media three-branched; no fold connecting the anal vein with Cu_2	TANYDERIDAE.
	Radius four-branched, media two-branched or simple; a fold connecting the anal vein with Cu_2	PTYCHOPTERIDAE.
18.	Venation little reduced, radius four-branched	19
	Venation more reduced, radius at most three-branched	20
19.	Veins and wing-margin with fine hair only; R_{2+3} arched and forming an angle with the sector	DIXIDAE.
	Veins and wing-margin fringed with long scales; R_{2+3} straight and generally continuous with the sector	CULICIDAE.

20. Subcosta indistinct; radius generally forking near middle of wing; basal flagellar segment of antennae not swollen and conical .. .. CHIRONOMIDAE.
Subcosta distinct and reaching costa; radius forking near base of wing; basal flagellar segment of antennae swollen and conical .. .. ORPHNEPHILIDAE.

GENERAL REMARKS ON THE NEW ZEALAND CRANE-FLY FAUNA.

The material on which this paper is based consists of (1) a collection presented by Mr. G. V. Hudson to the British Museum in 1920–21, consisting of duplicates of nearly all the species in his own unrivalled collection; (2) a further lot presented by Mr. Hudson to the Cambridge Museum in 1911, part of which has since been presented to the British Museum by Dr. H. Scott and Mr. C. G. Lamb; (3) a few specimens, including several cotypes, presented to the British Museum by the late Captain F. W. Hutton; (4) other material in the old collection of the British Museum, including Walker's types, chiefly collected by Dr. A. Sinclair, R.N., about 1850; (5) a small collection made in the neighbourhood of Auckland by Mr. Albert E. Brookes, and presented by him to the British Museum in 1919; (6) the Osten-Sacken collection in the Berlin-Dahlem Entomological Museum, lent by Dr. W. Horn, containing Osten-Sacken's and Alexander's types; (7) a considerable collection received on loan through Dr. C. P. Alexander, sent to him by Messrs. D. Miller, A. Philpott, and C. Speight; (8) the types (in the Cambridge Museum) of three species described by Mr. C. G. Lamb from Mr. Hudson's Auckland Islands collection; (9) a small collection made by C. M. Wakefield about 1880, now in the Oxford Museum, and including one of Westwood's types, lent by Professor E. B. Poulton; (10) a few specimens from Loew's collection in the Berlin Zoological Museum, lent by Dr. G. Enderlein.

I wish to tender my best thanks to all those who have assisted me in the ways indicated, particularly to Mr. G. V. Hudson, to whose generosity the British Museum is indebted for by far the greater part of its collection of New Zealand crane-flies. The total amount of material examined was so considerable, and included such a large proportion of the previously known forms, some of which, however, were very imperfectly known, that it seemed desirable to make this paper a preliminary revision of the crane-fly fauna of New Zealand.

Up to the end of 1920 there were sixty-seven species of these families known from New Zealand (I have sunk three names as synonyms and revived three others). Of these species I have been able to recognize all but twelve in the collections examined, and have added no fewer than ninety-two new ones, an increase of nearly 150 per cent. About half a dozen of the new forms are of somewhat doubtful validity as species, but, even if in the future all these are sunk as synonyms or varieties, their places will certainly be far more than filled by future discoveries: among the smaller and more obscure forms especially it is safe to assume that large accessions of new species have still to be made known. Meanwhile it may be remarked that the number of known species is even now nearly as great as in the British Islands, and very nearly half as great as the whole number of New Zealand Diptera recorded by Hutton in his *Index Faunae Novae Zealandiae* in 1904.

The crane-fly fauna as a whole shows some very interesting features. Not the least striking are some negative points—namely, the absence of

the genus *Tipula*, which is so abundantly represented in the Northern Hemisphere, as well as in South America, though it is absent from Australia; also of the genus *Eriocera*, so abundant in the Oriental and Neotropical regions. Other groups which, so far as our present knowledge goes, appear to be absent from New Zealand are the Ptychopteridae, the Mycetobiinae, the Cylindrotomini, the Pediciini, the Ctenophorini, and such widely distributed genera as *Limnobia*, *Rhipidia*, *Erioptera*, and *Nephrotoma*. Some of these gaps will doubtless be filled in time.

Apart from the Tanyderidae, which seem to be more strongly represented here than in any other region, the number of highly archaic forms in these families is not very great. The representatives of the Limnophilini and the Tipulinae, however, are clearly of an early type, and less advanced than the majority of the species of these groups in the rest of the world (Australia excepted). The genus *Cerozodia* is of special interest, as it appears to form a connecting-link between the Limnobiinae and the Tipulinae.

So far as can be ascertained at present, almost every species is endemic. The two possible exceptions are *Anisopus neozelandicus* and *Trimicra* sp., the former of which may occur in Australia, while the latter may not be distinct from the cosmopolitan *T. pilipes*.* The genera *Rhamphophila*, *Tinemyia*, and *Hudsonia*, and the subgenera *Aphrophila* and *Astelobia*, are also endemic, so far as our present knowledge goes.

In regard to relationship with other faunas, the crane-flies give much the same indications as would be expected, in view of our knowledge of other groups of animals. The strongest resemblance is naturally to the Australian fauna, as indicated by the species of *Molophilus* and the genera *Amphineurus*, *Gynoplistia*, and *Cerozodia*, as well as by *Limnophila subinterventa* and some other species of this genus. Certain groups are common to Australia, New Zealand, and South America, such as *Orolimnophila*, *Macromastix*, and perhaps the *hudsoni* group of *Limnophila*. Other species seem to be nearer to South American forms than to any known from Australasia; these are the *Tanyderus*, *Holorusia*, and perhaps the *Nemopalpus*. Yet other forms seem to show definitely Holarctic relationships—for example, *Dicranomyia vicarians*, the genus *Discobola* (especially *D. tesselata*), *Elephantomyia zealandica*, and *Longurio dux*. There do not appear to be any species indicating any connection with the Oriental or Ethiopian faunas. Some further remarks on the affinities of the species will be found in the body of this paper.

A point which deserves special mention is that, of the 160 species now known, only nineteen are definitely known from both North and South Islands, while of the remainder over seventy are recorded only from North Island and about forty only from South Island. A considerable number of species seem to be represented by closely allied forms in the two Islands. The great difference which these facts appear to indicate is no doubt in part due to the still very incomplete state of our knowledge and the small number of individuals of most species which have been collected, but there can be very little doubt that there is a strong line of demarcation.

A very interesting feature of the fauna is the number of species which are semiapterous in the female sex—a number which is probably greater than would appear from this paper, since so many species are known from

* A New Zealand specimen was identified by Osten-Sacken as *Trimicra pilipes* in 1886.—G. V. H.

males only. These semiapterous females follow the usual rules of being either inhabitants of mountains at high altitudes (the species of *Cerozodia* and *Gynoplistia*) or else winter insects (*Macromastix zeylandiae* and *Hudsonia heterogama*), or else inhabitants of oceanic islands (*Zaluscodes*). In this last case, as would be expected, the male is also semiapterous.

FAMILY ANISOPODIDAE (RHYPHIDAE).

Following Alexander, and in accordance with recent researches on the larvae and pupae, three subfamilies of the Anisopodidae may be recognized—

(1.) Mycetobiinae.—Radius three-branched; media two-branched.
(2.) Anisopodinae.—Radius three-branched; media three-branched.
(3.) Trichocerinae.—Radius four-branched; media three-branched.

No representatives of the Mycetobiinae are known as yet from New Zealand. The genera *Nervijuncta* Marshall, *Arctoneura* Hutton, and *Casa* Hutton, which have been referred to the Mycetobiinae, really belong to the subfamily Ditomyiinae of Mycetophilidae, as I have shown in a recent publication.

Subfamily ANISOPODINAE.

The only genus of this subfamily at the present known from New Zealand is *Anisopus*, but it is not at all improbable that the related *Olbiogaster* will eventually be found there.

Genus ANISOPUS Mg., 1804 (*Rhyphus* Latr., 1805).

As I have recently shown, the name *Anisopus* must replace *Rhyphus*, if the International Nomenclature Rules are to be strictly followed. Since our conception of the relationships of the genus has undergone a radical revision during the last few years, and the limits of the family have been extended to include *Mycetobia* and *Trichocera*, it will possibly be of advantage rather than otherwise that a change of name should be made at the same time. Two species of the almost cosmopolitan genus *Anisopus* are known from New Zealand, one of which apparently occurs also in Australia.

Anisopus neozelandicus (Schin.). (Fig. 3.)

Rhyphus neozelandicus Schiner, *Reise der "Novara," Dipt.*, p. 49.
Rhyphus phaleratus Walker (nom. nud.), *List Dipt. Brit. Mus.*, vol. 50, p. 124, 1848.

Flagellum of antennae yellow except towards tip. Thoracic markings indistinct, margin of mesonotum not darkened. Wing-tip darkened, but some pale areas included, the darkening being most distinct on veins; cell R_1 dark brown except at base; tip of costal cell dark brown; vein R_{2+3} moderately sinuous. As in the following species, the female wing is broader than that of male. Length of body, 7 mm.; wing, 9 mm.

NORTH ISLAND: Auckland (*Sinclair*); Mount Albert, Auckland (*A. E. Brookes*). SOUTH AUSTRALIA: Moonta, 16th November, 1904 (*W. Wesché*); one female in British Museum. As Mr. Wesché also collected in New Zealand, and the species is not otherwise known from Australia, it seems possible that a mistake in labelling has occurred.

Anisopus notatus (Hutton). (Figs. 1, 2.)

Rhyphus notatus Hutton, *Trans. N.Z. Inst.*, vol. 34, p. 191, 1902.
Rhyphus undulatus, Lamb, *Subantarctic Is. N.Z.*, p. 131, 1909.

Flagellum of antennae all black. Mesonotum with dark border, and with three more or less distinct praescutal stripes. Wing-tips uniformly darkened; cell R_1 dark brown at tip, before which is a large yellow spot extending into tip of cell C; vein R_{2+3} strongly sinuous.

North Island: Auckland (*Suter*); Hawera (*Wesché*); Wellington (*Hudson*). South Island: Christchurch (*Hutton*); Nelson (*Wesché*). Auckland Island (*Hudson*). This species rather closely resembles the European *A. fenestralis*, but differs in the contigous eyes of male and in other points. Colour of thorax and of scape of antennae is variable, as are wing-markings to a slight extent.

Subfamily TRICHOCERINAE.

Genus Trichocera Mg.

A single species has been recorded from the region under consideration, all the others occurring in temperate and cold regions of the Northern Hemisphere. The venation is almost identical with that of the Limnophilini, in which tribe the genus was till recently placed. The extreme shortness of vein Ax forms a ready means of identification, but it may be noted that certain true Limnophilini found in Australia also have this vein very short.

Trichocera antipodum Mik.

Trichocera antipodum Mik., *Verh. z.-b. Ges. Wien*, vol. 31, p. 200, 1882.

A small dark species with unmarked wings, which differs from the other species in the shortness of the ovipositor (approaching the allied genus *Diazosma* in this respect) and in the rather different venation, vein Cu_1 having only a punctiform contact with the discal cell before the middle, and Cu_2 being slightly concave above as in *Anisopus*. These points are of considerable interest as confirming the relationship with *Anisopus*, which the larval and pupal morphology proves to be real.

Auckland Island (*Krone*).

Family TANYDERIDAE.

Subfamily TANYDERINAE.

Genus Tanyderus Philippi.

This extremely interesting primitive genus is apparently confined to the Southern Hemisphere. The closely allied *Protoplasa*, which differs chiefly in its short neck and in the shape of cell R, is represented by three species in North America, and it is probable that the species *Tanyderus beckeri*, recently described by Riedel from the Caucasus, is more properly a *Protoplasa*, since in the two characters mentioned it agrees with the American species, though differing from them in having no cross-vein in cell M_3. The fossil species *Macrochile spectrum* Lw., from the Oligocene amber of the Baltic, hardly differs from *Protoplasa*.

The other species of *Tanyderus* are from South America (two), New Guinea (one), and Amboina (one). These differ from one another and

from the New Zealand species in the number of antennal joints, and the number and position of the extra cross-veins on the wings. I do not follow Handlirsch in treating these differences as of generic value. The New Zealand species all have sixteen-jointed antennae and two accessory cross-veins, these being situated in cells R_3 and R_4. The neck is elongate in all, though less so in *T. varipes*.

The structure of the aedoeagus of *Tanyderus* has not hitherto been described. In the three species of which I have seen males it is very remarkable, the penis being formed like Neptune's trident, each of the three prongs having a terminal opening; the whole organ has thin outer and thick inner walls. There are no parameres and no anal cerci. This structure is far from being primitive, and is very different from what occurs in any of the Ptychopteridae, in which *Tanyderus* was till recently included.

Tanyderus annuliferus Hutton. (Figs. 4, 5.)

Tanyderus annuliferus Hutton, *Trans. N.Z. Inst.*, vol. 32, p. 48, 1900.

Wing-markings distinctly ocellate, especially in male, in which sex the markings are lighter than in female; veins are yellow in light parts of wing; the two accessory cross-veins rather widely separated, the one in cell R_3 much beyond base of R_3; discal cell closed by two nearly equal veins. Legs yellow, the femora with a blackish pre-apical ring, other joints black-tipped. The trifid penis has a rather short stalk; lateral branches are turned outwards slightly at tips. Length of body, ♂ 13 mm., ♀ 17 mm.; wing, ♂ 15 mm., ♀ 18 mm.

NORTH ISLAND: Wellington district (*G. V. Hudson*, No. 102).

Tanyderus forcipatus Osten-Sacken. (Fig. 7.)

Tanyderus forcipatus Osten-Sacken, *Verh. z.-b. Ges. Wien*, vol. 39, p. 520, 1879.

Tanyderus forcipatus Hutton, *Trans. N.Z. Inst.*, vol. 32, p. 49, 1900.

Mischoderus forcipatus Handlirsch, *Ann. Hofmus. Wien*, vol. 23, p. 263, 1909.

Apart from darker colour, different wing-markings, dark veins, and black antennae, this species differs from *T. annuliferus* in several structural points: the hair on veins is much shorter; the cross-vein in cell R_3 is nearer base of R_3; the discal cell is differently shaped; and the tarsi are relatively shorter, those of the hind legs scarcely any longer than the tibiae. The tibiae and the tarsal joints are much more narrowly tipped with brown, not black.

The two specimens I have examined (both females, in the Oxford Museum) differ from one another in some respects. The one of which a figure of the wing is given appeared to agree very well with Osten-Sacken's description. The other had the legs somewhat shorter and stouter, apparently somewhat more densely pubescent; the oblique wing-fascia connected in the discal cell with the curved fascia; vein M_3 somewhat more approximated to Cu_1. There is no doubt, however, that both belong to the same species.

SOUTH ISLAND: Otago (*Hutton*). Osten-Sacken's type male, and two females in Oxford Museum, were all collected by C. M. Wakefield, probably from Canterbury. Hutton's record from Wellington requires confirmation, as it may have referred to *T. neptunus*.

Tanyderus neptunus n. sp. (Figs. 6, 123.)

Differs from *T. forcipatus* chiefly in wing-markings, the dark areas being more extensive and confluent; apart from this the veins are much stouter than in female of *T. forcipatus* (Osten-Sacken's figure also appears to indicate slender veins for the male of his species), axillary cell narrower, especially on apical portion, and stem of halteres is almost entirely dark. Prongs of the penis straighter than in *T. annuliferus*, and borne on longer stalk.

North Island: Wainuiomata, Wellington, 2nd December, 1898 (*G. V. Hudson*, No. 114b); type male in British Museum.

Probably the North Island representative of *T. forcipatus;* it may be a mere individual or sexual variation, but by analogy with *T. annuliferus* and *T. varipes* one would not expect to find male wings so much darker than those of female.

Tanyderus varipes n. sp. (Figs. 8, 9.)

Allied to *T. forcipatus*, but smaller, and of stouter build, antennae, neck, legs, wings, and halteres being shorter than in *T. forcipatus*, this being especially noticeable in female sex. Front much broader in both sexes than in *T. forcipatus*, nearly one-quarter as broad as head. Pronotum with a pair of blackish-brown spots, which are at most faintly indicated in *T. forcipatus*. Female cerci black (in *T. forcipatus* they are yellow). Prongs of penis straight and almost sessile. Femora with black pre-apical ring, preceded by an indistinct ochreous ring; tibiae broadly black at tips, a well-marked ochreous ring between the dark-brown basal portion and the black tip; first three tarsal joints ochreous, broadly black at tip, last two all black. Wings resembling those of *T. forcipatus*, but markings rather different, ground-colour of costal and subcostal cells yellowish, and M_3 curved downwards, so that cell M_3 is very narrow on margin. Wing-markings of male somewhat lighter, and veins much thicker than those of female. Length of body, ♂ 10 mm., ♀ 14 mm.; wing, ♂ 10 mm., ♀ 13 mm.; hind leg, ♂♀ 19 mm.

South Island: Bold Peak, Lake Wakatipu, 3,600 ft., near waterfall, 8th January, 1921 (*G. V. Hudson*, No. 114); type male and one female in British Museum.

Subfamily BRUCHOMYIINAE.

Genus Nemopalpus Macq.

Dr. C. P. Alexander informs me that he possesses a wing of a new species of this genus from New Zealand. It is otherwise known only from Recent and fossil species in the Palaearctic region, but may have been overlooked elsewhere. The allied genus *Bruchomyia* has recently been described by Alexander from South America, and made the type of a new subfamily.

Text-fig. A.—*Nemopalpus molophilinus* (Edw.): wing, × 40.

To assist in the identification of the genus in New Zealand I reproduce my figure of the fossil species *N. molophilinus* (Edw., 1921) from Baltic amber (text-fig. A).

FAMILY TIPULIDAE.

The two subfamilies may be separated as follows :—

Vein, Sc_1 present; fusion of Cu with M_3 nearly always long; free part of Cu_1 generally almost in a line with M	LIMNOBIINAE.
Vein Sc_1 usually absent; fusion of Cu_1 with M_3 nearly always very short or punctiform; free part of Cu_1 far from being in a line with M	TIPULINAE.

Subfamily LIMNOBIINAE.

The tribes occurring in New Zealand may be separated as follows :—

1.	Tibiae without spurs	2
	Tibiae with spurs, sometimes very small	Limnophilini.
2.	Antennae fourteen-jointed	Limnobiini.
	Antennae sixteen-jointed, twelve-jointed in *Ceratocheilus* ..	3
3.	Rostrum greatly elongated (in New Zealand genera) ..	Antochini.
	Rostrum not elongated	Eriopterini.

Tribe **Limnobiini.**

Only two genera of this tribe occur in New Zealand: *Discobola*, with a cross-vein in cell An, and *Dicranomyia*, without this cross-vein.

Genus DICRANOMYIA Stephens.

A large genus, with numerous representatives in all parts of the world. The species do not, as a rule, show much structural diversity, but such of their life-histories as are known are surprisingly varied. The majority of the New Zealand species show no special modifications, but the eight species treated below as Division I form a distinct group, distinguished principally by the structure of the male antennae. A species of this group has been described by Skuse from Australia, but I know of no other outside New Zealand. The somewhat elongate proboscis of several species of this group must not be taken as indicating any very close relationship with *Geranomyia*, since the palpi and the general facies of the insects are quite different; *Geranomyia* has no doubt been derived from quite a different group of *Dicranomyia*.

The New Zealand species may be separated by the following key :—

1.	Joints of flagellum of male antennae with distinct necks ..	2
	Joints of flagellum of male antennae without necks	9
2.	Stigma faint, at least for the greater part	3
	Stigma conspicuous	5
3.	Femora with pre-apical dark ring	*sublacteata* n. sp.
	Femora without trace of ring	4
4.	Legs rather slender	*flavidipennis* n. sp.
	Legs stouter	*decincta* n. sp.
5.	A dark cloud along Cu in cell M	6
	No such cloud	7
6.	Wing-tip scarcely darkened	*cubitalis* n. sp.
	Wing-tip distinctly darkened	*crassipes* n. sp.
7.	A large dark spot over base of Rs	*huttoni* n. name.
	A minute dark spot over base of Rs	8
8.	Pleurae with a distinct blackish stripe	*melanogramma* n. sp.
	Pleurae not striped	*octava* n. sp.
9.	Wings with distinct markings, at least the stigma obvious ..	10
	Wings unmarked, even the stigma scarcely perceptible ..	19
10.	A large dark spot near middle of cell R	*fasciata* Hutton.
	No such spot present	11

11. A large dark band on apical fourth of costa .. .. *repanda* n. sp.
 No such marking 12
12. Wings mainly dark ; a broad pale band before the stigma .. *fumipennis* Butler.
 Wings otherwise 13
13. Cross-veins at least slightly clouded 14
 Cross-veins perfectly clear 18
14. Abdomen uniformly dark above 15
 Abdomen with distinct ochreous bands 17
15. Base of Rs distinctly clouded 16
 Base of Rs practically clear .. .. *conulifera* n. sp.
16. Praescutum dull .. .. *hudsoni* n. sp.
 Praescutum shining .. .. *tenebrosa* n. sp.
17. Hairs of veins towards tip of wing scarcely noticeable .. *vicarians* Schin.
 These hairs fairly obvious .. .. *insularis* Mik.
18. Femora light brown ; stigma small and round .. .. *aegrotans* n. sp.
 Femora dark brown with a yellowish pre-apical ring .. *brookesi* n. sp.
19. Sc_1 ending close to base of Rs 20
 Sc_1 ending much before base of Rs 24
20. Blackish-brown species 21
 Pale-yellowish species 22
21. Flagellar joints oval .. .. *nigrescens* Hutton.
 Flagellar joints globular .. .. *kroni* Mik.
22. Discal cell absent, media with only one free branch .. .. *conveniens* (Walk.).
 Venation normal 23
23. Whole body pale ochreous .. .. *sulphuralis* n. sp.
 Palpi and abdomen brownish .. .. *luteonitens* n. sp.
24. Larger, yellowish-brown .. .. *monilicornis* Hutton.
 Smaller and darker 25
25. Flagellar joints globular .. .. *gracilis* n. sp.
 Flagellar joints oval .. .. *weschei* n. sp.

Division I.

Flagellar joints with distinct necks, at least in male. Proboscis as long as the head or a little longer. Ninth tergite of male hypopygium with conspicuous black bristles on the lobes.

Dicranomyia flavidipennis n. sp. (Figs. 10, 124.)

Head dark greenish-grey ; front narrow, scarcely one-sixth as broad as head. Proboscis ochreous, labella and palpi black ; length of proboscis about one-half greater than that of head, reckoning from extreme base to tip of labella. Antennae with scape brown, flagellum blackish ; flagellar joints with short necks in both sexes, necks less than one-half as long as joints, scarcely any longer in male than in female. *Thorax* uniformly ochreous, somewhat shining. *Abdomen* ochreous, with blackish median dorsal stripe, much more conspicuous in male than in female. Hypopygium—ninth tergite with pair of slender projections, laterally placed ; rostrum with two short curved spines. Ovipositor—anal valves reaching slightly beyond genital valves ; the former rather long, curved upwards, the latter long, nearly straight, black at base. *Legs* moderately slender, uniformly ochreous, only tips of tarsi darker. *Wings* with a uniform yellowish tinge ; the only darkening is a blackish border to marginal cross-vein, apart from which stigma is scarcely perceptible. Sc_1 ending a little beyond base of Rs, Sc_2 close to its tip. Halteres ochreous. *Length* of body, 5–7 mm. ; wing, 7–8 mm.

South Island : Bold Peak, Lake Wakatipu, 3,600 ft., 10th January, 1920 (*G. V. Hudson*, No. 192) ; type male and two females in British Museum.

Dicranomyia decincta n. sp. (Figs. 12, 125.)

Differs from *D. flavidipennis* as follows: Necks of flagellar joints fully half as long as joints. Legs somewhat stouter. Wings with stigma more distinct, though not very conspicuous. Veins in apical half of wing darker. Processes of ninth tergite shorter, broader, more rounded, and more bristly; rostrum more pointed, with two long, outwardly-directed spines.

SOUTH ISLAND: Bold Peak, Lake Wakatipu, 3,600 ft., 10th January, 1920 (*G. V. Hudson*, No. 192); type male (unique) in British Museum.

Dicranomyia sublacteata n. sp. (Figs. 11, 126.)

Head greyish-ochreous, front and middle of occiput sometimes brown; front narrow, scarcely one-sixth as broad as head. Proboscis ochreous, about half as long again as head, labella and palpi dark brown. Antennae with scape brown, flagellum blackish; flagellar joints with distinct necks; in male the necks are nearly as long, in female only one-third as long, as joints themselves. *Thorax* ochreous, scarcely shining; praescutum with indications of three darker stripes; pleurae somewhat dusted with grey. *Abdomen* ochreous, with narrow median and lateral blackish lines; these lines are more conspicuous in male than in female, in which segments 6–8 are almost entirely black. Hypopygium—ninth tergite with a pair of rounded processes, placed close together; rostrum with two long, slightly curved spines. Ovipositor—anal valves reaching slightly beyond genital valves; the former rather long, curved; the latter long, straight, black at base. *Legs* moderately slender, brownish-ochreous, tibiae and tarsi somewhat darker, femora with a rather ill-defined blackish ring just before tip. *Wings* creamy-tinged, slightly opaque (whence the specific name); stigma scarcely perceptible; in female there is a dark cloud along Cu in basal half of cell M, which is only very faintly indicated in male; veins round tip of wing dark. Halteres ochreous, tip of knob blackish. *Length* of body, 7–8·5 mm.; wing, 8–9 mm.

SOUTH ISLAND: Bold Peak, Lake Wakatipu, 3,600 ft., 10th January, 1920 (*G. V. Hudson*, No. 192): type male, two other males, and three females, in British Museum; also one male and one female in Cambridge Museum.

Dicranomyia cubitalis n. sp. (Figs. 14, 127.)

Head dark-greyish, front and median line on occiput brown. Proboscis (including labella) dark brown, scarcely longer than head; labella and palpi black. Antennae with scape dark brown, flagellum blackish; necks of flagellar joints as long as joints in male, only one-quarter as long in female. *Thorax* brownish-ochreous, slightly dusted with grey; praescutum with indications of three darker stripes. *Abdomen* brownish-ochreous, with black median and lateral stripes, broader in male, segments 6–8 mostly black (more so in male). Hypopygium—ninth tergite with two large rounded projections, close together, with V-shaped excavation between them; rostrum bent, with two spines, rather widely separated, one being longer than the other. Ovipositor as in *D. sublacteata*. *Legs* moderately slender, dark brown, femora somewhat lighter towards base, and with blackish ring near tip, preceded by a slightly paler ring not always distinguishable; tips of tibiae blackish. *Wings* nearly colourless; stigma conspicuous, blackish; cross-veins narrowly dark-margined; small brown dot over base of Rs; dark cloud along Cu in cell M, more distinct in female;

veins all dark; wing-tip in female with a scarcely perceptible darkening. Rs sometimes obtusely angulated. Halteres ochreous with dark knob. *Length* of body, 5·5–8 mm.; wing, 7–9 mm.

NORTH ISLAND: Tamaki, 10th August, 1917 (*A. E. Brookes*), type male and one female; New Plymouth, 23rd September, 1906 (*W. Wesché*), one female; Wellington (?) (*G. V. Hudson*, No. 73E), one female — all in British Museum; Te Wairoa, 15th November, 1919, one male and one female, in Mr. Miller's collection. SOUTH ISLAND: Otago (*Osten-Sacken*), three females, in Berlin-Dahlem Museum, labelled "*monilicornis* O.-S.," in Osten-Sacken's handwriting.

Dicranomyia crassipes n. sp. (Fig. 16.)

♀. Differs from *D. cubitalis* as follows: Head without dark median line. Proboscis (including labella) more than half as long again as head. Thorax and abdomen darker, abdomen without distinct lateral and median lines. Legs, especially femora, considerably stouter. Wing-tip distinctly darkened. Base of Rs thickened.

NORTH ISLAND: Karori, Wellington, in bush, November, 1920 (*G. V. Hudson*, No. 73); type female (unique) in British Museum.

Dicranomyia huttoni n. name. (Fig. 15.)

Geranomyia annulipes Hutton, *Trans. N.Z. Inst.*, vol. 32, p. 35, 1900 (*nec Dicranomyia annulipes* Skuse, 1889).

A female specimen which I take to be this species shows the following diagnostic points: Proboscis fully half as long again as head. Necks of flagellar joints about half as long as joints. Praescutum ochreous, with three dark stripes, lateral pair very short. Pronotum, scutellum, postnotum, and mesopleurae entirely dark brown. Coxae and propleurae pale ochreous. Hind-margins of abdominal segments conspicuously pale. Ovipositor with anal valves only half as long as last segment; genital valves curved, slender. Dark pre-apical rings of femora very distinct. Rs strongly angulated near base, a stump arising from angle, and a rather large brown spot covering it. Stigma distinct; cross-veins distinctly clouded; spot over the tip of Rs; wing-tip and cell M clear.

I have seen only the wing of a male specimen, so can give no characters for the hypopygium, but the species is undoubtedly distinct from any of the seven new ones described in this group.

NORTH ISLAND: Wellington (*Hudson* [*according to Hutton*]); Te Wairoa, 11th November, 1919, one female and wing of male, in Mr. D. Miller's collection.

Dicranomyia melanogramma n. sp. (Figs. 13, 128.)

Head dark-greyish. Front very narrow, not one-tenth as broad as head. Proboscis, palpi, and antennae blackish-brown, scape lighter. Proboscis nearly half as long again as head. Flagellar joints in male with long necks, slightly longer than joints, which, however, are very prominent ventrally, with rounded tips directed somewhat forwards; the verticil-hairs on upper surface of each joint somewhat longer than the whole joint, including neck, those on under-surface are short; last joint long and slender, as long as the two preceding joints together. In female antennae are shorter, necks less than half as long as the more oval joints. *Thorax* ochreous-brown, somewhat shining: an indistinct median dark stripe on

mesonotum; a rather broad and conspicuous blackish stripe on pleurae, extending from neck to base of abdomen. *Abdomen* dark brown, lighter beneath; hind-margins of the segments broadly ochreous. Hypopygium —ninth tergite with a median suture; a pair of small bristly projections in middle, on each side of which are three or four strong bristles; rostrum blackened, with two rather short spines, one longer than the other. Ovipositor—anal valves shorter than segment bearing them, strongly curved, reaching slightly beyond tips of genital valves, which are slender, curved, and black at base. *Legs* brown, femora lighter, with a distinct black ring at tip in male, a dark-brown ring slightly before tip in female. *Wings* with a slight uniform brownish tinge; stigma conspicuous, dark brown; cross-veins slightly clouded; base of Rs slightly thickened, practically clear. Halteres blackish, base of stem ochreous. *Length* of body, 6 mm.; wing, 7·5 mm.

North Island: Karori, Wellington, in bush, November, 1920 (*G. V. Hudson*, No. 73); type male and one female in British Museum.

Dicranomyia octava n. sp. (Fig. 129.)

♂. *Head* blackish-grey. Front narrow, about one-tenth the width of head. Proboscis scarcely longer than head, basal portion dark brown, labella ochreous. Palpi black. Antennae blackish, scape brown; flagellum as in *D. melanogramma*. *Thorax* almost uniformly ochreous, scarcely shining; an ill-defined darker spot in middle of pleurae. *Abdomen* mostly blackish; hind-margins of first two segments light. Hypopygium—ninth tergite with a broad, shallow, V-shaped terminal emargination; ventral lobe of side-piece stout; rostrum with two rather long spines, greatly swollen at their bases. *Legs* slender, brownish; femora lighter, with narrow, ill-defined darker ring just before their tips. *Wings* colourless; veins dark; stigma distinct, dark brown; very slight cloudings at base of Rs and over cross-veins, noticeable only with a lens; wing-tip and cell M clear. Halteres with ochreous stem and dark knob. *Length* of body, 5·5 mm.; wing, 7 mm.

South Island: Mount Grey, Canterbury, 11th April, 1917; type male (unique) in collection of Canterbury Museum.

Division II.

Flagellar joints without necks. Proboscis hardly as long as head. Ninth tergite of male hypopygium without conspicuous black bristles apically.

Dicranomyia fasciata Hutton.

Dicranomyia fasciata Hutton, *Trans. N.Z. Inst.*, vol. 32, p. 34, 1900.

"Greyish-brown; coxae and lower surface lighter. Wings hyaline; a large fuscous spot near middle of anterior basal cell, just inside the origin of second longitudinal vein, another in centre of marginal cell, and a small spot at origin of third longitudinal vein. Inner and outer margins of discal cell and posterior cross-vein bordered with fuscous. Auxiliary vein ends slightly outside origin of second longitudinal; posterior cross-vein lies inside base of discal cell. Rostrum shorter than head. Joints of flagellum submoniliform. Length, ♀ 7 mm.; wing, ♀ 9 mm. Male unknown."—(*Hutton*).

South Island: Christchurch (*Hutton*).

Dicranomyia repanda n. sp. (Fig. 17.)

Limnobia repanda Walker (nom. nud.), *List. Dipt Brit. Mus.*, vol. 1, p. 57, 1848.

♂. *Head* black; front somewhat dusted with grey, nearly one-quarter as wide as head. Proboscis ochreous, shorter than head. Palpi black. Antennae black, first scapal joint brownish; flagellar joints oval, becoming gradually more slender towards apex of antennae; verticils not longer than joints. *Thorax* reddish-brown, mesonotum somewhat shining; praescutum with three obscurely darker stripes; pleurae grey-dusted. *Abdomen* ochreous-brown, hypopygium somewhat darker; ninth tergite with two large rounded lobes; fleshy claspers very large, nearly four times as long as side-pieces (pleurites); rostrum very short, with two short spines. *Legs* ochreous-brown, tarsi darker; femora with an obscure dark ring before the tip. *Wings* slightly milky, with broad dark band over the cord, and another from stigma to tip of wing, continued, though more faintly, from wing-tip to tip of Cu_2. Small dark spot in base of cell R; dark dot over Sc_2, and another over base of Rs. Sc_1 ending slightly beyond, Sc_2 placed far before base of Rs. Rs shorter than first section of R_{2+3}. Discal cell elongate, nearly three times as long as its breadth at apex. Halteres brownish-ochreous. *Length* of body, 9–11 mm.; wing, 11–12 mm.

North Island: Karori, Wellington (*G. V. Hudson*, No. 72); type male presented in 1906, a second male in 1920. Walker's specimen (now very much damaged) was collected by Dr. Andrew Sinclair, but no locality is recorded.

Dicranomyia fumipennis (Butler). (Fig. 18.)

Limnobia fumipennis Butler, *Cistula Entomologica*, vol. 1, p. 355, 1875.

♀. *Head* and appendages blackish. Proboscis as long as head. Flagellum shrivelled, joints apparently nearly round, apical ones more oval. *Thorax* and *abdomen* almost uniformly dark brown. Ovipositor with anal valves long, slender, almost straight, reaching far beyond end of genital valves. *Legs* dark brown. *Wings* brownish-tinged over greater part of surface, stigma and seam over cord very little darker; a rather broad whitish band just before stigma, extending from R to Cu; cell 2nd M_1 mostly whitish. Sc_1 ending immediately before base of Rs; Sc_2 close to tip of Sc_1; discal cell scarcely twice as long as broad. Halteres brownish. *Length* of body, 10 mm.; wing, 13 mm.

I know this species only from Butler's type female, which is in fairly good condition, in British Museum. Its exact locality is unknown.

Dicranomyia hudsoni n. sp. (Fig. 19.)

Head blackish, somewhat grey-dusted, front almost silvery in certain lights, about one-quarter as broad as head. Proboscis black, shorter than head. Palpi and antennae black. Basal flagellar joints shortly oval, outer joints becoming gradually more slender; verticils shorter than joints. *Thorax* dark brown, mesonotum dusted with ochreous, pleurae with grey, propleurae and margin of mesonotum and of scutellum ochreous. *Abdomen* brownish, hypopygium somewhat lighter; venter pale ochreous, at least in male. Hypopygium similar to that of *D. repanda*, but the fleshy claspers somewhat shorter, scarcely three times as long as side-pieces. Ovipositor—both pairs of valves slender and nearly straight, and valves as long as last

segment. *Legs* brownish, tarsi darker apically; extreme tips of tibiae black. *Wings* slightly brownish-tinged, a little darker at tip, a little clearer before and beyond stigma and in discal cell. Stigma distinct, elongate. Dark seam over the cord and apex of discal cell; distinct dark spot over base of Rs, and dark spot over Sc_2. Sc_1 ending distinctly beyond. Sc_2 considerably before base of Rs. Discal cell two to three times as long as its breadth at apex. Halteres ochreous. *Length* of body, 8 mm.; wing, 11–12 mm.

South Island: Bold Peak, Lake Wakatipu, near waterfall, 3,600 ft. (*G. V. Hudson*, No. 271); one male and one female presented to British Museum in 1921; another male (the type of the species) presented by the collector to Cambridge Museum in 1911, and by Dr. H. Scott to British Museum in 1920.

Dicranomyia tenebrosa n. sp. (Fig. 20.)

♀. *Head* dark-brownish-grey, front dusted with pale grey, about one-fifth as broad as head. Proboscis black, scarcely as long as head. Palpi black. Antennae black; basal flagellar joints rounded, last six or seven joints oval; verticils somewhat shorter than joints. *Thorax*—praescutum shining blackish-brown, with small ochreous areas on shoulders. Scutum shining blackish-brown at sides, grey-dusted in middle. Scutellum grey-dusted in middle, ochreous at sides and on hind-margin. Postnotum blackish, somewhat shining. Pleurae dark brown, heavily dusted with pale grey. *Abdomen* uniformly dark brown, somewhat shining. Anal valves of ovipositor very slender, straight, as long as last segment. Genital valves moderately long and stout, not blackened at base. *Legs* dark brown, femora somewhat lighter at base, their apices somewhat clubbed but not blackened. *Wings* with very faint brownish tinge; stigma conspicuous, dark brown; cross-veins, apex of discal cell, and extreme tip of wing slightly clouded. Sc_1 about as long as Rs, its tip slightly beyond base of Rs. Discal cell scarcely twice as long as broad, shorter than cell M_1. Halteres with ochreous stem and dark-brown knob. *Length* of body, 8 mm.; wing, 9 mm.

South Island: Kinloch, Lake Wakatipu, January, 1921 (*G. V. Hudson*, No. 304); type female in British Museum, other examples in Mr. Hudson's collection.

Dicranomyia conulifera n. sp. (Fig. 21.)

♀. *Head* brownish, heavily dusted with grey; front about one-eighth as broad as head. Proboscis light brown, about as long as head. Palpi dark brown. Antennae dark brown, scape somewhat lighter. Flagellar joints scarcely longer than their greater breadth, which is near apex, the joints therefore being somewhat conical in shape, though without distinct pedicels or necks; joints decrease only slightly in size to the penultimate; last joint elongate, as long as two preceding joints together. *Thorax* brownish-ochreous, mesonotum dusted with ochreous, pleurae with grey; praescutum with three separate and rather distinct dark-brown stripes. *Abdomen* rather dark brown, unmarked, last segment and ovipositor reddish. Anal valves of ovipositor slender, straight, a little longer than last segment; genital valves rather stout at base, more slender on their apical half. *Legs* moderately slender, light ochreous-brown, tips of femora slightly clubbed and slightly darkened. *Wings* with a slight milky-greyish tinge, veins brown. Stigma light brown, almost entirely internal to marginal

cross-vein. A very faint clouding over cross-veins. Sc_1 about twice as long as Sc_2, ending above or immediately before base of Rs. Rs nearly straight, more than half as long as R_{2+3}. Discal cell about half as long again as broad. Halteres ochreous. *Length* of body, 6 mm.; wing, 6·5 mm.

NORTH ISLAND: Mount Albert, Auckland, 29th May, 1915 (*A. E. Brookes*); type and one other female in British Museum.

Dicranomyia vicarians Schiner. (Fig. 130.)

Limnobia vicarians Schiner, *Reise der "Novara," Dipt.*, p. 46, 1868.
Dicranomyia vicarians, Mik., *Verh. z.-b. Ges. Wien*, vol. 31, p. 196, 1881.
Dicranomyia annulata Lamb, *Subantarctic Is. N.Z.*, p. 129, 1909.
Limnobia chorica Walker (nom. nud.), *List Dipt. Brit. Mus.*, vol. 1, p. 44, 1848.

Head blackish. Proboscis about half as long as head. Antennae black, the flagellar joints oval, last four or five and especially last one rather elongate. *Thorax* ochreous, somewhat shining; praescutum darker in middle. *Abdomen* ochreous, apical half of each segment dark brown. Hypopygium—lobes of ninth tergite rather densely hairy apically. Fleshy clasper large, about twice as long as side-piece; rostrum with two short spines, one much thicker than the other. Ovipositor much as in *D. aegrotans* and *D. conulifera*. *Legs* slender, brownish, tips of femora darker. *Wings* nearly hyaline; stigma rather dark brown; distinct brown spot over base of Rs; cross-veins, vein Cu, and tip of Ax somewhat clouded. Sc_1 about two-thirds as long as Rs, ending close to base of Rs, either slightly before or slightly beyond it. Halteres with pale-ochreous stem and dark-brown knob. *Length* of body, 5·5–7 mm.; wing, 6–7·5 mm.

NORTH ISLAND: Auckland (*Schiner*); Tamaki, 10th August, 1917 (*A. E. Brookes*), one male in British Museum; Titirangi, 30th December, 1915 (*A. E. Brookes*), one damaged specimen. Also two males and one female in Walker's series of *L. chorica*, without locality. SOUTH ISLAND: Otago (*Osten-Sacken*); one female in Berlin-Dahlem Museum. AUCKLAND ISLANDS (*Krone, Hudson*): Type male and female of *D. annulata* in Cambridge Museum.

Dicranomyia insularis Mik.

Dicranomyia insularis Mik., *Verh. z.-b. Ges. Wien*, vol. 31, p. 197, 1881.

♂. Differs from *D. vicarians* Schin. in the slightly longer hairs on veins towards apex of wing, and in structure of male hypopygium; rostrum rather longer and more slender, the two spines on it rather longer, and both of about same thickness; the fleshy clasper much shorter and of more irregular shape.

AUCKLAND ISLANDS (*Krone*).

Dicranomyia aegrotans n. sp. (Fig. 22.)

Limnobia aegrotans Walker (nom. nud.), *List. Dipt. Brit. Mus.*, vol. 1, p. 45, 1848.

♀. *Head* heavily dusted with light ash-grey; front apparently about one-fifth as broad as head. Proboscis and palpi dark-brown, about half as long as head. First antennal joint grey-dusted, remainder blackish;

flagellar joints rounded, the last six or seven shortly oval; verticils slightly longer than joints. *Thorax* brown, heavily dusted with pale grey; praescutum with three stripes of brown ground-colour. *Abdomen* dark brown, last segment and ovipositor reddish. Anal valves of ovipositor slender, curved, slightly shorter than last segment; genital valves somewhat narrowed on apical half. *Legs* rather light brown, tips of femora slightly darker. *Wings* rather narrow, with slight milky tint; base of wing and veins Sc and R white, the rest dark; Cu slightly clouded; stigma dark brown, small, roundish, bisected by the cross-vein. Sc_1 ending slightly beyond the base of Rs, scarcely twice as long as Sc_2, which is oblique. Rs gently curved, about twice as long as basal section of R_{4+5} and nearly two-thirds as long as R_{2+3}. A distinct fold crossing the *r-m* cross-vein. Discal cell fully twice as long as broad, open to cell M_1 on one wing. Halteres light ochreous. *Length* of body, 5 mm.; wing, 6 mm.

Known only from Walker's female, now made the type of the species, which is still in good condition in British Museum. The species is so distinct that it seems worth describing, even though the locality of the type is unknown.

Dicranomyia brookesi n. sp.

Head blackish; front slightly grey-dusted, rather narrow, apparently less than one-sixth as broad as head. Proboscis dark brown, about half as long as head. Palpi and antennae black; flagellar joints all oval, last six rather elongate, verticils slightly longer than joints. *Thorax* shining dark brown; an ochreous band on each side of mesonotum. *Abdomen* uniformly dark brown above, including hypopygium; venter pale ochreous. Hypopygium—ninth tergite with two rounded lobes. Fleshy claspers extremely large, fully three times as long as side-pieces; rostrum with two short spines, well separated, the outer (or more apical) one slightly shorter and distinctly stouter than the inner (or more basal). Horny claspers strongly and uniformly curved. Ovipositor—anal valves slender, straight, slightly longer than last segment; genital valves rather stout, evenly tapering. *Legs* slender, dark brown; femora each with a narrow, rather sharply defined yellowish ring just before tip. *Wings* uniformly and rather strongly tinged with brown; veins dark brown; stigma distinct, rather dark brown; a scarcely perceptible dark seam over cross-veins. Sc_1 ending opposite or slightly beyond base of Rs, a little more than half as long as Rs. (Sc_2 absent in one specimen.) Rs about half as long as R_{2+3}. Discal cell about half as long again as broad. Halteres blackish, base of stem ochreous. *Length* of body, 5–6 mm.; wing, 7–8·5 mm.

NORTH ISLAND: Hunua Ranges, 1st January, 1916 (*A. E. Brookes*), four males (including type) in British Museum; Karori, Wellington, 14th April, 1913 (*G. V. Hudson*, No. 296B), one female in British Museum.

Dicranomyia nigrescens Hutton.

Dicranomyia nigrescens Hutton, *Trans. N.Z. Inst.*, vol. 32, p. 34, 1900.

"Dark fuscous, almost black, ovipositor reddish. Wings unspotted, dark fuscous. Rostrum about as long as head in female. Joints of flagellum of antennae oval. Auxiliary vein ending slightly beyond origin of second longitudinal. Posterior cross-vein in a line with base of discal cell. Length, ♀ 8 mm.; wing, ♀ 11 mm. Male unknown."—(*Hutton.*)

North Island: Wellington (*Hudson*). Mr. Hudson writes that the specimen of *D. nigrescens* in his collection is slightly larger and more slender than *D. brookesi*, femora are without the pale ring, and stigma not so dark.

Dicranomyia kronei Mik.

Dicranomyia kronei Mik., *Verh. z.-b. Ges. Wien*, vol. 31, p. 199, 1881.

♂. Almost uniformly blackish-brown. Flagellar joints globular. Hypopygium—fleshy claspers scarcely longer than side-pieces; rostrum rather short and blunt, without spines; horny clasper long, slightly curved and evenly tapering. Wings brownish, without markings, stigma faint. Sc_1 about twice as long as Sc_2, ending a little beyond the base of Rs. Rs quite two-thirds as long as R_{2+3}. Discal cell about half as long again as broad. Length of body, 6 mm.; wing, 8 mm.

Auckland Islands (*Krone*). The above characters are drawn from Mik's description.

Dicranomyia luteonitens n. sp. (Fig. 24.)

♂. *Head* dull greyish-ochreous, paler on front, which is about one-sixth as broad as head. Proboscis pale-yellowish, shorter than head. Palpi brown. Antennae with scape ochreous, flagellum black; flagellar joints mostly globular, last few shortly oval; verticils slightly longer than joints. *Thorax* considerably shining, rather light ochreous, slightly darker in middle of mesonotum, middle of pronotum brownish. *Abdomen* light brown, hypopygium lighter, in structure much resembling that of *D. conveniens*, but the horny upper clasper not at all contracted in middle, and inner lobes of parameres are very broad, rounded apically. *Legs* uniformly brownish-ochreous. *Wings* hyaline; stigma absent; veins light brown. Sc_1 longer than Rs and ending immediately before base of Rs. Discal cell small, not much longer than broad. Halteres with ochreous stem and dark knob. *Length* of body, 4·5 mm.; wing, 6 mm.

North Island: Mount Albert, 11th December, 1916 (*A. E. Brookes*), one male (type) in British Museum; also a second damaged specimen from the same place, 20th November, 1915.

This seems to be near Hutton's *D. monilicornis*, but is smaller, and, the localities being widely separated, the two are not very likely to be the same.

Dicranomyia conveniens (Walker). (Figs. 23, 131.)

Limnobia conveniens Walker, *List Dipt. Brit. Mus.*, vol. 1, p. 57, 1848.

♂. Entirely pale ochreous, including palpi and wing-veins. (Flagellum of antennae missing in both specimens.) Front about one-quarter as wide as head. Proboscis shorter than head. Thorax scarcely shining, mesonotum a little darker than pleurae. Hypopygium with large fleshy claspers, nearly twice as long and about twice as broad as side-pieces; rostrum short, with two short spines near base, both equally stout. Horny upper clasper somewhat narrowed in middle. Inner lobes of parameres very slender. Wings hyaline, stigma absent. Sc_1 ending slightly before base of Rs, only about twice as long as Sc_2. Discal cell absent; only one free branch of media present.

North Island: Titirangi, 30th December, 1915 (*A. E. Brookes*); one male in British Museum. Walker's type male, also in British Museum, is still in recognizable condition, but there is no record of where it was obtained.

The reduced venation renders the species an easily recognizable one so far as the New Zealand fauna is concerned, though it is certainly very closely related to *D. luteonitens*. The same reduction of the media occurs in a few Malayan and American species.

Dicranomyia sulphuralis n. sp. (Fig. 132.)

Body entirely pale ochreous, almost sulphur-yellow, only eyes and flagellum of antennae black, knob of halteres somewhat darkened. Hypopygium—fleshy claspers very large, quite three times as long as side-pieces. Horny upper claspers small, curved, not narrowed in middle. Rostrum short, its two spines short and placed so close together that in the dry specimen they appear as a single spine. Parameres rather broad, but somewhat pointed. Ninth tergite with very broad V-shaped emargination. Wings hyaline, veins all pale, stigma absent. Sc_1 twice as long as Rs, its tip slightly before base of Rs. Rs slightly shorter and more curved than basal section of R_{4+5}. Discal cell about half as long again as broad. Length of body, about 4·5 mm.; wing, 6 mm.

NORTH ISLAND: Te Wairoa, 16th November, 1919 (*D. Miller*); one male.

Dicranomyia monilicornis Hutton.

Dicranomyia monilicornis Hutton, *Trans. N.Z. Inst.*, vol. 32, p. 34, 1900.

"Yellowish-brown; rostrum, coxae, and lower surface of body lighter; antennae and palpi darker. Wings unspotted, slightly fuscous, the costa yellowish-brown; veins fuscous. Rostrum about the length of head in female, shorter in male. Flagellum of antennae submoniliform in both sexes. Legs hairy. Auxiliary vein ends some distance inside origin of second longitudinal; posterior cross-vein in line with base of discal cell. Length, ♂ 6–7 mm., ♀ 6–7 mm.; wing, ♂ 8–9 mm., ♀ 9 mm."—(*Hutton.*)

SOUTH ISLAND: Christchurch (*Hutton*).

Although the specimens in the Berlin-Dahlem Museum (see note under *D. cubitalis*) show that this was not the species for which Osten-Sacken had intended the name *monilicornis*, Hutton's name must be used for it.

Dicranomyia gracilis n. sp. (Figs. 25, 133.)

Limnobia gracilis Walker (nom. nud.), *List Dipt. Brit. Mus.*, vol. 1, p. 44, 1848.

Head dark greyish-ochreous, with black hairs rather longer than usual. Front about one-fifth as broad as head. Proboscis brownish, slightly shorter than head. Palpi and antennae dark brown. Flagellar joints globular, last four or five rather shortly oval; verticils a little longer than joints. *Thorax* moderately dark brown, scarcely shining, but without obvious dusting. Praescutum with broad, slightly darker central stripe, confluent behind with pair of short lateral stripes. *Abdomen* uniformly rather dark brown. Hypopygium—ninth tergite narrow; with very shallow rounded emargination; side-pieces very long and narrow; claspers modified from usual type, upper horny one reduced to small pale bristle, lower one more slender and hairy and less fleshy than usual, folded inwards, without spines, but with tuft of rather long hairs at tip. Ovipositor—anal valves slender, straight, slightly longer than last segment; genital valves rather short and stout, straight. *Legs* uniformly brown. *Wings* slightly and uniformly tinged with greyish-brown, stigma no darker, veins rather dark. Sc_1 about

twice as long as Sc_2, ending before base of Rs, much more so in male than in female; in male base of Rs is at about two-thirds of wing-length, in female a little nearer base of wing, and the vein is consequently rather longer. Discal cell about half as long again as broad. Halteres rather dark brown. *Length* of body, 5 mm.; wing, 6–6·5 mm.

NORTH ISLAND: Wellington (*G. V. Hudson*, No. 103B), one male type, in British Museum. I think Walker's female specimen is probably the same species, in spite of the differences of venation indicated above. It is probably related to Hutton's *D. monilicornis*, but seems to be smaller and darker; there are evidently a number of related species in this group, and an examination of Hutton's type will be necessary before it can be satisfactorily identified.

Dicranomyia weschei n. sp.

Head blackish; front rather heavily dusted with pale grey, apparently about one-fifth as broad as head. Proboscis brownish, shorter than head. Palpi dark brown. Antennae black, flagellar joints all rather shortly oval; verticils a little longer than joints. *Thorax* ochreous-brown, praescutum and scutum blackish-brown, except for shoulders and small area on each side just in front of suture. Pleurae slightly dusted with grey. *Abdomen* dark brown, last segment and ovipositor reddish. Anal valves of ovipositor slender, almost straight, little longer than last segment; genital valves rather short and stout. *Legs* dark brown; coxae and bases of femora lighter. *Wings* faintly and uniformly brownish-tinged, rather strongly iridescent; stigma darker brown, but not very conspicuous. Sc_1 about as long as Rs and ending well before base of Rs, which is short and originates just before two-thirds of wing-length. Halteres rather long, dark brown, base of stem light. *Length* of body, 6 mm.; wing, 7·5 mm.

NORTH ISLAND: New Plymouth, 23rd September, 1906 (*W. Wesché*); type female (unique) in British Museum.

Genus DISCOBOLA O.-S., 1865 (TROCHOBOLA O.-S., 1869).

A small genus, principally developed in New Zealand, but with representatives also in Europe (two), North America (two), and Australia (one). None are known from the Oriental region, where the type appears to be represented by the allied genus *Libnotes*.

The New Zealand species at present known may be distinguished by the following key:—

1. Wings with numerous dark dots over the greater part of the surface; no distinct ocellate markings	2
Wings with markings more or less ocellate, without numerous dark dots	4
2. A dark streak along costal margin of wing from base to tip..	*striata* n. sp.
A triangular dark area surrounding the stigma	3
3. Discal cell elongate and irregularly shaped	*picta* Hutton.
Discal cell not elongate	*venusta* O.-S.
4. Distinct ocellate markings in the neighbourhood of the stigma	5
A large dark patch surrounding the stigma	6
5. Light-ochreous species	*tesselata* (O.-S.).
Darker species; pleurae shining black	*gibbera* n. sp.
6. Only two light areas on the costa	*fumipennis* (Hudson).
Three light areas on the costa	7
7. Wings with an uninterrupted central dark fascia	*ampla* (Hutton).
Wings with central fascia interrupted	8
8. A complete ring round base of Rs	*dicyla* n. sp.
Ring round base of Rs incomplete	*dohrni* (O.-S.).

Discobola striata n. sp. (Figs. 32, 134.)

Head dark grey, with blackish central stripe; frons more ochreous, strongly dusted. Proboscis about as long as head, black. Palpi black. Antennae rather light ochreous, first scapal and first flagellar joints darker. First two or three flagellar joints almost globular, separated by short necks; remaining joints gradually more oval and more slender. *Thorax* rather pale ochreous-grey. Pronotum dark at sides and with dark-brown central stripe extending backwards nearly whole length of praescutum. Mesonotum with rather broad dark-brown stripe on each side, between which and narrow central stripe are some minute brown dots. Scutellum dark brown at sides; postnotum light-brownish, greyer in middle. Pleurae with rather irregular dark-brown stripe, reaching from front coxae to sides of postnotum. *Abdomen* rather dark brown, somewhat shining. Hypopygium with single pair of claspers which are somewhat square, with projecting lobe at each corner; those on outer and inner basal corners apparently represent the horny clasper and rostrum of *Dicranomyia;* inner apical lobe beset with numerous minute spines; parameres divided into two elongate lobes. *Legs* pale ochreous, dark-brown ring just before tip of each femur; last three tarsal joints dark. *Wings* (see fig. 32) very distinctive on account of dark-brown stripe extending along costal margin from humeral cross-vein to tip of wing, broadening out on apical half. Below this stripe is a nearly clear streak, the rest of wing being filled with dark dots. Cross-vein *m* situated far beyond base of M_3, giving discal cell a peculiar shape, as in *D. picta.* Halteres long, pale ochreous, knob and narrow ring at base of stem blackish. *Length* of body, 7·5–8 mm.; wing, 10–11 mm.

NORTH ISLAND: Karori, Wellington (*G. V. Hudson*, Nos. 79c and 791); type and one other male in British Museum. Rare.

Discobola picta (Hutton). (Fig. 31.)

Trochobola picta Hutton, *Trans. N.Z. Inst.*, vol. 32, p. 37, 1900.

Does not differ much from *D. striata* except in wing-markings, but in this is so distinct that the two must be treated as distinct species. Shape of discal cell the same in both. Differences may be found in male hypopygium.

NORTH ISLAND: Wellington (*Hudson*). I have seen two female specimens, one in British Museum and one at Cambridge.

Discobola venusta (Osten-Sacken). (Fig. 30.)

Trochobola venusta Osten-Sacken, *Berlin ent. Zeitschr.*, vol. 34, p. 265, 1894; Hutton, *Trans. N.Z. Inst.*, vol. 34, p. 190, 1902.

Nearly related to *D. striata* and *D. picta*, but with different wing-markings (see fig. 30), and with quite differently shaped discal cell, which is closed by two straight veins of equal length. Hypopygium similar to that of *D. striata*, but there are a number of small differences—*e.g.*, spine at outer basal corner of clasper is stronger and projects outwards. In both these species the clasper contains a curious internal vesicle.

SOUTH ISLAND: Greymouth (*Helms*), recorded by Osten-Sacken. I have seen specimens from Tisbury, 28th November, 1915, and Mount Grey, November, 1914.

Discobola tesselata (Osten-Sacken.) (Figs. 33, 34.)

Trochobola tesselata Osten-Sacken, *Berlin. ent. Zeitschr.*, vol. 39, p. 266, 1894.
Trochobola variegata Hutton, *Trans. N.Z. Inst.*, vol. 32, p. 36, 1900.
Limnobia tesselata Walker (nom. nud.), *List Dipt. Brit. Mus.*, vol. 1, p. 45, 1848.

This species differs from all the others as yet known from New Zealand in the predominating light-ochreous colour of thorax and abdomen. Praescutum has four dark stripes, middle pair narrow and widely separated; postnotum has a blackish band down middle. Hypopygium has claspers resembling those of *Dicranomyia*—a slender, curved, horny upper pair, and a fleshy lower pair provided with an inwardly-projecting rostrum; rostrum does not bear spines, but there is a pair of straight slender rods on the fleshy clasper itself near base of rostrum. Quite distinct from *D. australis*; it has not the strongly produced praescutum of that species, and differs in many details of coloration.

The name *tesselata* must be attributed to Osten-Sacken, who gave a very brief diagnosis of Walker's specimen; this was just sufficient to validate the name, and necessitates sinking Hutton's *T. variegata* as a synonym. The species is extremely similar to the North American *D. argus* and the European *D. annulata*—more so than to any other New Zealand species.

North Island: Wellington district (*G. V. Hudson*, No. 229). Walker's specimen (a male) is unlabelled as to locality. There are also two females in British Museum, presented by Mr. Hudson.

Discobola gibbera n. sp. (Fig. 29.)

Head blackish, heavily dusted with dark grey; front narrow, not more than one-tenth as broad as head. Probiscis and palpi blackish, about half as long as head. Antennae dark brown, second scapal joint light brown. Flagellar joints all about same length, but becoming gradually more slender; basal joints very shortly oval; terminal joints rather elongate oval. *Thorax*—pronotum green. Praescutum strongly humped, arching forwards over pronotum more than in any other New Zealand species, brown, somewhat dusted with greyish-brown, with short dark-brown stripe on each side. Scutellum and postnotum shining blackish-brown. Pleurae mostly shining black, a small ochreous spot in middle, and a greenish area over hind-coxae. *Abdomen* dark brown, with narrow pale rings extending over apices and bases of segments. Ovipositor with anal valves curved, slightly shorter than last segment; genital valves stout, rather blunt-ended, evenly tapering. *Legs* ochreous; femora with a narrow black ring at tip; extreme tip of tibiae and last two tarsal joints dark. *Wings* with a faint ochreous tinge; venation and markings as in fig. 29. Halteres ochreous at extreme base, then with rather broad blackish ring; apex of stem and base of knob pale ochreous, apex of knob blackish. *Length* of body, 9 mm.; wing, 9 mm.

South Island: Tisbury, 31st October, 1915 (A. Philpott); one female. Type in Cawthron Institute collection.

Most nearly allied to *D. australis* Skuse, differing in leg-markings and some other points. From *D. tesselata* it differs in the more humped thorax, colour of pleurae and postnotum, femoral markings, &c.

Discobola dicycla n. sp. (Fig. 28.)

Similar to *D. dohrni* and *D. ampla*, and perhaps a variety of one or other, but shows the following differences: Flagellar joints all about equal in length, but becoming slightly and gradually more slender towards apex; last joint under four times as long as broad; hairs on upper surface rather conspicuous, somewhat longer than joints. Pronotum rather bright ochreous, strongly contrasting with dark head and thorax. Abdomen also conspicuously paler than thorax. Wing-markings resembling those of *D. dohrni*, but those in centre separated from those at base and from those towards apex; a complete ring surrounding base of Rs and another below this, the two forming central fascia. Discal cell somewhat longer than in the other two species. Length of body, 9 mm.; wing, 11 mm.

SOUTH ISLAND: West Plains, 4th March, 1906 (A. Philpott); one female. Type in Cawthron Institute collection.

Discobola dohrni (Osten-Sacken). (Fig. 27.)

Trochobola dohrni Osten-Sacken, *Berlin. ent. Zeitschr.*, vol. 39, p. 264, 1894; Hutton, *Trans. N.Z. Inst.*, vol. 34, p. 189, 1902.

The last six or eight joints of flagellum distinctly elongate, especially last joint, which is about six or seven times as long as broad; hairs on upper surface are inconspicuous, shorter than joints. Pronotum and abdomen dark brown, like the remainder of body. Base of Rs covered by small brown spot, this being surrounded by an incomplete dark ring, broken outwardly below Rs. Basal two-thirds of the cell M practically filled by an undivided dark patch. Length of body, 12–16 mm.; wing, 13–23 mm. (according to Osten-Sacken).

SOUTH ISLAND: Recorded by Osten-Sacken from Christchurch (*Hutton*) and Greymouth (*Helms*). I have seen a male and female from White Rock, 26th October, 1920, from Canterbury Museum, and a female without definite data in British Museum.

Discobola ampla (Hutton). (Fig. 26.)

Trochobola ampla Hutton, *Trans. N.Z. Inst.*, vol. 32, p. 36, 1900.

This was regarded by Hutton as identical with *D. dohrni*, but according to the specimens I have examined there are certain differences, which may be only varietal, but ought not to be disregarded. In *D. ampla* the flagellar joints are all about equal in length, though they become gradually more slender towards apex; last joint is only about four times as long as broad; hairs on upper surface somewhat shorter than joints. Pronotum somewhat lighter than rest of thorax, though not conspicuously so. Wing-markings more extensive and more consolidated than in *D. dohrni*; in particular, there is an uninterrupted band across middle of wing, including base of Rs and tip of An. Cell M dark except for two pale spots near apex. Length of body, 11–14 mm.; wing, 14–20 mm.

NORTH ISLAND: Wellington (*G. V. Hudson*); one female in British Museum, from Wilton's Bush, 11th October, 1914; also one male in Cambridge Museum.

Discobola fumipennis (Hudson).

Tipula fumipennis, Hudson, *Man. N.Z. Ent.*, p. 48, pl. v, fig. 2, 1892.

Given by Hutton as a synonym of *D. ampla*, but, although it may be a *Discobola*, it seems incredible that the very different wing-markings shown

in Hudson's figure can represent the same species. If it is really the same, Hudson's name must be used in place of Hutton's, since the figure and descriptive matter are sufficient to validate the publication of it.

Tribe **Antochini.**

Genus Elephantomyia O.-S.

Antennae fifteen-jointed, the basal flagellar joint not much swollen, the remaining joints oval and all with moderately long hairs. Proboscis about as long as the abdomen or longer, with minute palpi inserted at its tip. Praescutum not noticeably produced over the neck. Sc_1 ending far beyond the base of Rs. R_2 long, nearly parallel with R_{4+5}, and ending not far from tip of wing. An straight, not closely approximated to Cu at base.

A small but more or less cosmopolitan genus. Five species are known from the Ethiopian region, two or three from the Oriental region, two from Austro-Malayan islands, one from the West Indies, and one from North America, which is said to occur also in central Europe. The New Zealand species rather closely resembles this last.

Elephantomyia zealandica n. sp. (Fig. 35.)

♀. *Head* dark ochreous-brown; front grey-dusted, about one-eighth as broad as head. Antennae dark brown, first scapal joint ochreous. Flagellar joints all about equal, except the first, which is somewhat swollen, and the second, which is small and indistinctly separated from the first. Proboscis dark brown, twice the length of thorax. *Thorax* dull ochreous-brown, without grey dusting. Praescutum with blackish median line in front. A dark-brown vertical stripe on pleurae just in front of wing-base, extending over middle coxae. *Abdomen* ochreous, apical three-fourths of each tergite blackish-brown. *Legs* slender, dark brown, front and hind coxae and trochanters ochreous. *Wings* with slight brownish tinge, stigma and veins dark brown. Venation normal for the genus. Halteres blackish, stem ochreous towards base. *Length* of body, about 7·5 mm.; wing, 7·5 mm.; proboscis, about 4 mm.

South Island: Lake Wakatipu, 1906 (*G. V. Hudson*); type female in British Museum.

Genus Ceratocheilus Wesché.

Antennae twelve-jointed, the basal joint of the flagellum swollen, the remaining joints small; the last few joints with long hairs, the remainder nearly bare. Proboscis nearly or quite as long as abdomen, with minute palpi inserted at its tip. Praescutum conically produced over the neck. Sc_1 ending near base of Rs. R_2 short, more or less waved, divergent from R_{4+5}, ending in costa far before wing-tip and close to tip of R_1. An bent just before the middle, basal portion almost in contact with Cu.

This is a small genus of wide distribution in the tropics, with about six species in the Ethiopian, two in the Oriental, and two in the Neotropical region. None are recorded as yet from Australia. The Ethiopian species differ from the others in having spotted wings and a long projection (corniculus) on the front of the head a little above the antennae; there is no trace of this in the New Zealand species.

Ceratocheilus levis (Hutton). (Fig. 36.)

Rhamphidia levis Hutton, *Trans. N.Z. Inst.*, vol. 32, p. 38, 1900.

♀. Antennae entirely black. Proboscis nearly twice as long as thorax. Head mostly dark brown, grey round eyes. Mesonotum dark grey, with slight ochreous tinge, heavily dusted; three blackish-brown praescutal stripes, not quite confluent, leaving two narrow lines of greyish ground-colour. Pleurae and postnotum black, heavily dusted with dark grey. Abdomen blackish-brown, somewhat grey-dusted. Legs very slender. Wings rather dark-greyish. Sc_1 ending a short distance beyond, Sc_2 placed a similar distance before the base of Rs. R_2 gently waved. Cu_{1a} very slightly beyond base of discal cell. Length of body, 7·5 mm.; wing, 7 mm.; hind leg, 14 mm.; proboscis, 4·5 mm.

NORTH ISLAND: Wellington district (*G. V. Hudson*, No. 161). I have seen two females, one from Wilton's Bush, 1st December, 1920. They are precisely alike.

Ceratocheilus ochraceum n. sp. (Fig. 37.)

♂. Scape of antennae ochreous-brown. Proboscis considerably less than twice the length of thorax. Head more extensively grey than in *C. levis*, the middle blackish. Mesonotum ochreous on borders, praescutal stripes absolutely confluent, dull dark brown. Pleurae ochreous, without distinct dusting. Postnotum ochreous at sides, slightly shining dark brown in middle. Abdomen brownish-ochreous, incisures and seventh segment darker. Hypopygium—ninth tergite with two bluntly triangular points, rather widely separated; outer claspers very short. Inner claspers bent inwards near base, a triangular marginal tooth beyond the bend; side-pieces with small dark basal tubercle. Legs longer and somewhat stouter than in *C. levis*. Wings tinged with ochreous-grey; Sc_1 not longer than Sc_2, ending a little before base of Rs; R_2 somewhat shorter than in *C. levis* and practically straight. Cu_{1a} well beyond base of discal cell. Length of body, 7 mm.; wing, 6·5 mm.; hind leg, 15·5 mm.; proboscis, 3·2 mm.

NORTH ISLAND: Wilton's Bush, Wellington, in forest, 1st December, 1920 (*G. V. Hudson* No. 161B); type male in British Museum. Although this was taken at the same place and on the same day as a female of *C. levis*, the differences are so considerable that I feel bound to recognize two distinct species. Sexual dimorphism does not occur in any species of *Ceratocheilus* known to me.

Tribe **Eriopterini.**

The following key will distinguish the genera found in New Zealand:—

1.	Radius three-branched; Sc ending near base of Rs	*Gonomyia*, subgenus *Lipophleps*.
	Radius four-branched; Sc ending at or beyond the apex of Rs	2
2.	Middle legs considerably shorter than the others	3
	Middle legs as long as the front ones	*Gnophomyia*.
3.	Wings hairy, either on veins or membrane; cell Sc widened apically	4
	Wings with bare membrane; hair on veins inconspicuous; cell Sc not widened apically	*Trimicra*.
4.	Wing-membrane hairy	*Amphineurus*.
	Wing-veins densely hairy, membrane practically bare ..	*Molophilus*.

Genus Gonomyia (Mg.) O.-S.

Subgenus Lipophleps Bergroth, *Psyche*, vol. 22, p. 55, 1915.

(New name for *Leiponeura* Skuse, preoccupied by *Liponeura* Lw.)

This subgenus has rather numerous representatives in most tropical countries, the first known being *Gonomyia manca* O.-S., from North America. Recently Alexander has recognized that the two species of *Leiponeura* described from Australia by Skuse are referable to *Gonomyia*, and has adopted *Leiponeura* as a subgenus, describing many new species. The name *Leiponeura* cannot stand, in view of the previous existence of *Liponeura*, the difference being merely one of transliteration. I follow Alexander in regarding *Lipophleps* as a subgenus of *Gonomyia*, rather than as a distinct genus, as Bergroth claims it should be regarded.

Owing to the loss of the vein R_2, members of this subgenus are liable to be confused with *Dicranomyia*, to which they have actually very little affinity. The sixteen-jointed antennae, the strongly divergent veins R_3 and R_{4+5}, and the structure of the male hypopygium will distinguish them. As in *Gonomyia* (s. str.), yellow or orange coloration is of frequent occurrence on the sides of the thorax and abdomen. The New Zealand species does not appear to be particularly closely allied to any of those described from Australia.

Gonomyia (Lipophleps) nigrohalterata n. sp. (Fig. 38.)

♀. *Head* light ochreous; proboscis more orange; palpi and antennae black. Flagellar joints rather elongate oval, the first five distinctly stouter than the rest, and with more numerous and rather shorter hairs; verticils on outer joints rather longer than joints. *Thorax* ochreous-orange, somewhat shining, without grey dusting; praescutum, and scutum except for middle quarter, dark brown. Pleurae with blackish line (not very conspicuous) running from neck to base of halteres. *Abdomen* brown above, more orange below. Ovipositor with anal valves slender, curved, a little longer than last segment. *Legs* dark brown, coxae and trochanters ochreous. *Wings* with slight greyish tinge; unmarked; stigma hardly perceptible. Sc_1 ending opposite base of Rs. Rs nearly straight, about equal in length to R_2. Cu_{1a} just before base of small discal cell. Halteres rather long, black, tip of knob lighter. Length of body, 5 mm.; wing, 5·5 mm.

North Island: Auckland, 16th September, 1906 (*W. Wesché*); type female in British Museum.

Genus Amphineurus Skuse (emended).

This name was proposed by Skuse (as a subgenus of *Rhypholophus*) for two Australian species which showed a striking peculiarity of venation in having the discal cell absent and cells M_1 and M_3 equal in length. I now propose to use the name in a full generic sense, and to include in it two New Zealand species having the same venation as those described by Skuse, and also three or four others with different venation. The differences between the species in venation are very striking, and might be thought to be of generic or subgeneric value, but the remarkable structure of the hypopygium is similar in all, and there can be no doubt that they are in reality closely related. It is equally certain that they are not so

closely related to any of the species of *Rhypholophus* and *Ormosia* found in Europe, and this fact will further justify their treatment as a single group. Whether this group is given generic or only subgeneric rank is immaterial; for convenience I prefer the former plan, particularly as I have regarded the two European groups as distinct genera. I know of no other representatives of this genus outside Australia and New Zealand. No members of the group of genera (*Amphineurus*, *Rhypholophus*, and *Ormosia*) have been described from the Neotropical region. In all three genera (or subgenera, if the term be preferred) the male hypopygium has undergone permanent torsion, so that the ninth tergite lies on the ventral side. The same occurs in *Molophilus*, and may indicate a closer relationship between these genera than any of them have to *Erioptera*, where the torsion does not occur.

Owing to the inclusion of these additional species, Skuse's definition of *Amphineurus* will require remodelling as follows: Discal cell present or absent; cell M_3 either sessile on M (as in the typical species) or stalked, owing to the long fusion of M_3 with Cu_1; M_3 never arising from M_1, as in nearly all the species of *Rhypholophus* and *Ormosia* found in the Northern Hemisphere. Ax long and sinuous (as in *Rhypholophus*). Side-pieces of male hypopygium with a long, finger-like terminal process.

The New Zealand species may be distinguished as follows:—

1.	Discal cell present; abdomen and wings densely scaly ..	*perdecorus* n. sp.
	Discal cell absent; abdomen moderately hairy	2
2.	Cell M_3 sessile	3
	Cell M_3 stalked	4
3.	Femora black with two narrow yellow rings	*bicinctus* n. sp.
	Femora with black, white, and brown rings	*hudsoni* n. sp.
4.	Dull, dark species without ornamentation	*horni* n. sp.
	Light species, or else with distinct ornamentation	5
5.	Legs all ochreous	*insulsus* (Hutton).
	Femora with two yellow rings	*fatuus* (Hutton).

Of these species, *A. horni* shows an approach to *Erioptera*, and *A. perdecorus* to *Molophilus*; the other four are much more closely allied.

Amphineurus perdecorus n. sp. (Figs. 41, 42, 135.)

Head black, with long whitish scaly pubescence. Antennae about as long as head and thorax together, brown; the flagellar joints rather darker in middle, all about equal in length, elliptical, with rather short fine pubescence and one or two long hairs on dorsal surface of each joint. *Thorax* with black integument, clothed in patches with long narrow creamy-white scales forming a rather indefinite pattern; just anterior to the mesonotal suture are two roundish tufts of dark-brown scales. Pubescence of pleurae of same colour but rather more hair-like. *Abdomen* densely covered with scales, pale-brownish at sides, dark in a median dorsal line; about half of the light scales are of peculiar form, like minute bladders, the remainder, as well as all the dark ones, very long and hair-like. Hypopygium—tips of side-pieces drawn out into long, very hairy processes, attenuated apically; three pairs of claspers, one situated at base of side-pieces, long, slender, serrate towards tip; the other two pairs short, stout, black, curved in opposite directions, lower one slightly bifid, at tip. Parameres long, bent in middle, outer half black, pointed. *Legs* densely covered with long hair-like scales, mostly black, but the femora are paler on basal third and have narrow yellowish ring beyond middle;

tibiae each have two yellowish rings, before and beyond middle; front metatarsi have yellowish ring near base, and mid and hind metatarsi a narrower ring at base. Front tarsi very long, nearly twice the length of tibia; tarsi of mid legs slightly longer, of hind legs slightly shorter, than respective tibiae. Mid legs extremely short, femora being hardly more than half as long as hind femora. *Wings* densely clothed on whole surface with hair-like scales of two colours, pale brownish-yellow and dark brown. The dark ones occur chiefly in a patch near base of costa; a small spot before one-third of wing-length just below radius, another small spot opposite this on hind-margin; a large irregular patch beyond middle extending from costa somewhat obliquely backwards more than half across wing; and an area round wing-tip, which includes several small pale spots on margin. Discal cell present; cross-vein *m* at tip of discal cell, equal in length to basal section of M_2; Cu_1 meeting M either at, or just before, or just beyond base of discal cell; Ax long and slightly arcuated. Cells R_2 and R_3 usually of almost the same length; often cell R_2 is distinctly the longer, as in *Molophilus;* Rs angled and generally spurred at base. Halteres yellow.

NORTH ISLAND: Kaitoke, Wellington, in forest, November and December (*G. V. Hudson*, No. 159); two males (including type) and one female in British Museum; one male in Cambridge Museum. Swanson, 30th November, 1916 (*A. E. Brookes*); one male in British Museum. The wing-markings exhibit some slight variation. When resting with closed wings this insect has a decidedly spider-like appearance.

Amphineurus bicinctus n. sp. (Fig. 136.)

Head dark grey densely covered with yellowish hair. Proboscis and palpi black. Scape of antennae ochreous; flagellum dark brown, except at base. Flagellar joints of male about three times as long as broad, nearly cylindrical, verticils a little longer than joints, the whole antenna scarcely longer than thorax. *Thorax*—pronotum, shoulders, and narrow line at the edge of praescutum whitish. Praescutum with three bluish-grey stripes, conspicuously bordered with velvet-black, the lateral stripes and their black borders extending on scutum. Scutellum mainly ochreous. Postnotum greyish-brown. Pleurae black, with broad whitish stripe from front coxae to halteres. *Abdomen* dark brown, velvet-black along lateral borders; hypopygium and ovipositor ochreous-brown. Processes of male side-pieces long and slender, apex very slightly swollen; three pairs of claspers, the longest almost as long as the hairy processes, pointed at tip and serrate on inner margin; ninth tergite in middle with a long smooth black process trifid at tip. Anal segment of female swollen, hairy; anal valves of ovipositor short, stout, curved almost into a semicircle. *Legs*—coxae and trochanters whitish-ochreous. Femora blackish, lighter at base, and each with narrow yellow rings on apical half; tip broadly black. *Wings* with dark-brown hair, on upper surface with numerous small patches of pale-ochreous hair in all the cells, and a small patch of deep-black hair at tip of Sc_1. On under-surface all the hair is dark brown. Discal cell absent; cells M_1 and M_3 of equal length, both square at base; Cu_{1a} joining M well before the fork. Halteres ochreous, with brown ring on stem. *Length* of body, 5 mm.; wing, 7 mm.

NORTH ISLAND: Karori, Wellington, in forest, November, 1920 (*G. V. Hudson*, No. 373): two males (including type) and one female in British Museum.

Amphineurus hudsoni n. sp. (Figs. 43, 137.)

Head dark grey, with some black hair. Proboscis and palpi black. Scape and base of flagellum of antennae ochreous, remainder dark brown. Antennae alike in the two sexes; flagellar joints about three times as long as broad, slightly thicker in middle, with verticils little longer than joints. *Thorax*—pronotum, a spot on the shoulders and another in front of wing-base yellowish. Mesonotum mainly occupied by three brownish-grey stripes, narrowly separated in front by dark-brown lines. Pleurae pale grey with some dark-brown markings. Postnotum brownish-grey with whitish spot on each side near base. *Abdomen* as in *A. bicinctus*, but male hypopygium has only two pairs of claspers, the third (middle) pair being represented by minute rudiments; upper pair longer and more slender than in *A. bicinctus*, smooth except for tip, which is blunt and serrated; ninth tergite has two large black pointed lobes. *Legs*—coxae pale ochreous, dusted with grey; trochanters ochreous. Femora ochreous-brown, with blackish ring close to base, and two other rather broad blackish rings, bordered on each edge with white; tip rather broadly ochreous-brown. Tibiae brownish-ochreous, with blackish ring near base, bordered with white; tip broadly black, preceded by narrow white ring. Tarsi blackish. *Wings* much as in *A. bicinctus*, but the pale hairs more numerous, especially in region of cord. Halteres ochreous. *Length* of body, 5 mm.; wing, 7 mm.

NORTH ISLAND: Karori, Wellington, November, 1920 (*G. V. Hudson*, No. 20); two males (including type) and one female in British Museum; also a second female (*G. V. Hudson*, No. 92B).

The larva feeds in the soft, wet, decayed portions of the fallen leaves of the nikau-palm (*Rhopalostylis sapida*).

Amphineurus insulsus (Hutton). (Figs. 39, 138, 139.)

Rhypholophus insulsus Hutton, *Trans. N.Z. Inst.*, vol. 34, p. 188, 1902.

A very distinct species, on account of the almost uniform light-ochreous colour of the whole body, as well as wings and legs; palpi, cross-veins, and tips of most of veins being blackish. The male antennae are considerably longer than the whole body, all the flagellar joints elongate (especially the first) and provided with long pubescence, nearly as long as joints; in female the antennae about half as long as body. Male hypopygium has long finger-like processes to side-pieces; two pairs of claspers, upper ones black, trifid almost to base, middle branch as long as hairy processes, strongly serrate on inner margin; the other two branches slender, sinuous, sharp-pointed; the lower pair short, brown. The wing-hair is all ochreous and evenly distributed over the surface. Length of body, 5 mm.; wing, 9 mm.

NORTH ISLAND: Wellington district (*G. V. Hudson*, No. 97); Te Wairoa, 15th November, 1919 (*D. Miller*). SOUTH ISLAND: Mount Grey, Canterbury, November, 1917.

Amphineurus fatuus (Hutton). (Figs. 40, 140.)

Rhypholophus fatuus Hutton, *Trans. N.Z. Inst.*, vol. 34, p. 188, 1902.

Also a very easily recognized species, on account of general dark-brown colour of body and two yellow rings on the black femora, the second ring being apical. Antennae in both sexes only about as long as thorax, but in male the flagellar joints are somewhat more swollen at bases than in female, and are covered with very long pubescence, three times as long as each joint. Male hypopygium essentially similar in structure to that of last three species, but very remarkable on account of its asymmetry. The side-piece of one side (the right in actual, left in morphological position)

has only one clasper, and this is of quite a different structure from either of those on the left side; the aedoeagus is also of remarkable construction and very asymmetrical. All the specimens are exactly alike, so that there can be no question of an accidental deformity. Although some species of *Gonomyia* have an asymmetrical aedoeagus, this is the first Nematocerous Dipteron I have seen with asymmetrical claspers. The wing-hair is all dark, but varies in density in different parts, and there are areas in basal, anal, and axillary cells which are devoid of hair. Length of body, 6 mm.; wing, 9 mm.

NORTH ISLAND: Karori and Wainuiomata, Wellington (*G. V. Hudson*, No. 135); three males and one female in British Museum.

Amphineurus horni n. sp. (Fig. 44.)

Whole body rather dark brown; back of head darker; coxae, anal segment, and ovipositor lighter. Antennae missing. Thorax heavily dusted with brownish. Anal segment swollen and rather short. Anal valves of ovipositor about as long as the segment, rather stout, curved almost into a semicircle, scarcely reaching beyond tips of genital valves. Middle legs dark brown (front and hind legs missing). Wings with membrane and veins greyish, hair dark brown. All veins rather densely clothed with long hair; hairs of an equal length are also scattered rather thinly over whole surface. Venation almost as in *Erioptera*: *r-m* and Cu_{1a} both meet M almost exactly at fork, and therefore form an obtusely-angled line. R_{2+3} strongly arched, a little longer than *r-m* and about two-thirds as long as stem of cell M_3. Ax rather short, very slightly arcuated, ending much before Cu_{1a}. Length of body, 3·5 mm.; wing, 5·2 mm.

NORTH ISLAND: Wellington (*G. V. Hudson*, No. 111A); type female in Berlin-Dahlem Museum. I have pleasure in naming the species after Dr. W. Horn, to whom I am indebted for the loan of several collections.

The position of this species in *Amphineurus* is somewhat uncertain, the venation approaching closely to that of *Erioptera*, and the long dense hair on the veins also suggesting an affinity with that genus. The somewhat hairy wing-surface, however, excludes it from *Erioptera*, and, as the ovipositor has the same structure as in *A. bicinctus*, it is probably correctly placed in *Amphineurus*.

Genus MOLOPHILUS Mg.

This genus is readily distinguished by two peculiarities of venation—the cell R_2 being considerably longer than R_3, and the cross-vein *r-m* being placed far beyond the first fork of the media; in addition the long dense hair on the wing-veins will distinguish it from other New Zealand genera, though not from *Erioptera*. In regard to the first point, an approach is made to *Molophilus* by *Amphineurus perdecorus*, but no confusion need be caused on that account. The genus is a cosmopolitan one.

The New Zealand species show some affinity—not, however, very striking—with those of Australia; they are of quite a different type, in regard to markings and hypopygial structure, from those of the Palaearctic and Nearctic regions. The following table will separate the known New Zealand forms:—

1.	Legs ringed	2
	Legs not ringed	4
2.	Legs yellow with black rings	*variegatus* n. sp.
	Legs dark with white rings	3
3.	Metatarsi with a white ring	*multicinctus* n. sp.
	Metatarsi (at least on middle legs) without white ring ..	*infantulus* n. sp.
4.	Legs and wings uniformly dark	*inornatus* n. sp.
	Legs yellow; wings spotted	*pulcherrimus* n. sp.

Molophilus pulcherrimus n. sp. (Fig. 45.)

♀. *Head* dark-brownish; proboscis and palpi black; antennae brown with black hair. Flagellar joints nearly cylindrical, about twice as long as broad, verticils about twice as long as joints. *Thorax* brownish-ochreous; praescutum with four dark-brown stripes and a few yellow hairs; pleurae with broad black stipe from neck to base of abdomen; sternopleura below this line dusted with light grey, as also coxae. *Abdomen* ochreous-brown, darker at sides. Anal valves of ovipositor moderately stout, strongly curved, as long as last segment, which is hairy and has a pair of little conical projections. *Legs* yellowish; front femora except at base with very dense blackish pubescence, rather longer than the yellow pubescence on the rest of the legs; front tibiae and tarsal joints also with black pubescence at tips. *Wings* with the membrane greyish-tinged, except for nine rounded spots round apical margin, between tips of veins. Hair on veins black, except on basal three-fifths of costa, Sc, R_1, Rs (except base), tip of Ax, and a space just before tip of An, where it is yellow. The hairs overlapping whitish spots on membrane are also yellow. Denser aggregations of black hair occur at base of Rs, along cord, and at tips of all veins. Some hairs on wing-membrane all round the apical border of wing. Tips of R_1, R_2, and R_3 turn upwards; those of M_1, M_2, Cu_1, and Cu_2 downwards. Ax long and sinuous, ending slightly beyond level of Cu_{1a}. Cu_{1a} joining M just beyond fork, short, nearly vertical, hairy. Halteres yellowish, stem darker. *Length* of body, 4 mm.; wing, 5 mm.

NORTH ISLAND: Wilton's Bush, Wellington, December (*G. V. Hudson*, No. 115B); type female in British Museum.

Molophilus multicinctus n. sp.

♂. *Head* dark grey, antennae and palpi brown. Antennae a little shorter than thorax; flagellar joints rather shortly oval, with long fine pubescence (about twice as long as joint) on under side, and two or three very long hairs (about four times as long as joint) on upper side. *Thorax* rather dark greyish-brown or buff; pleurae greyer; margin and interspaces of praescutum dark brown; postnotum and lateral sclerites darker. *Abdomen* dark brown, with long pale pubescence. Hypopygium yellowish; terminal process of side-piece very long, nearly twice as long as the short side-piece itself; claspers long, slender, whitish, with darkened tips; both pairs about equal in length, one pair pointed, the other with bulbous expansion close to rounded tip. *Legs* blackish, bases of femora lighter; each leg with five conspicuous white rings placed as follows: at two-thirds of length of femur; at femoro-tibial joint; before and beyond middle of tibia; and at base of first tarsal joint. The second of these rings is narrower than the others. *Wings* clothed mostly with dark hair, without distinct markings, but the hair is darker over the cord, and lighter before and beyond it. Numerous hairs on membrane in cell R_1. Cu_{1a} very oblique, hairy, reaching M just beyond fork, longer than stem of cell M_3. Ax long, sinuous, reaching hind-margin opposite base of M_3. Halteres yellowish, knob somewhat darker. *Length* of body, 4 mm.; wing, 4·5 mm.

Two males, without exact data (*C. M. Wakefield*, 1880); one cotype in Oxford Museum, one in British Museum.

Molophilus infantulus n. sp.

♀. *Head* brownish. Palpi black. Scape of antennae brown, flagellum black, joints nearly cylindrical, all about equal; verticils nearly three

times as long as joints. *Thorax* ochreous-brown, scarcely shining, with some black hair; no markings; pronotum yellow. *Abdomen* blackish, with brown pubescence; ovipositor ochreous-brown, anal valves strong, curved, slightly longer than anal segment, which is slightly hairy. *Legs* (middle leg alone present) dark brown, tibia with two rings of whitish pubescence, a very narrow one near base and a somewhat broader one near tip. *Wings* with slightly greyish membrane and dark hair. Cu_{1a} curved, hairy, less than half as long as stem of cell M_3. Ax nearly straight, ending a little beyond tip of Cu_{1a}. Halteres yellow. *Length* of body, 2·5 mm.; wing, 3 mm.

NORTH ISLAND: Titirangi, Auckland, 30th December, 1915 (*A. E. Brookes*); type female in British Museum. If the male of this species is smaller than the female (as is usually the case in this genus) it must be one of the very smallest members of the family.

Molophilus variegatus n. sp. (Fig. 46.)

Head shrivelled, apparently dull blackish-grey. Proboscis, palpi, and antennae dark brown. Flagellar joints all rather shortly oval, two or three at base somewhat swollen; verticils about three times as long as joints. *Thorax* somewhat shining, yellow, with black markings; hairs scanty, concolorous with integument from which they arise. Praescutum has four large, more or less semicircular black spots, all in contact, round margin, the whole central portion being yellow. Scutum with four black spots, the outer ones nearly semicircular and in contact with those of praescutum, the inner pair larger. Scutellum black. Postnotum black, yellow at base. Pleurae yellow, with small dark spot in middle and larger blackish area on lateral sclerites of postnotum. *Abdomen* light-brownish, hind-margins of segments yellowish; pubescence pale. Hypopygium black, the two pairs of claspers widely separated by membrane; one pair placed at bases of side-pieces and reaching just to their tips, base straight except for hooked tip; the other pair subapically placed, short, curved, pointed at tip. *Legs* yellow, with black rings at tips of all joints, before middle of the front femora, and near base of front and middle tibiae (hind legs missing). *Wings* with the membrane hyaline; hair mostly black; patches of yellow on Rs and on costa above it, in middle of R_2 and R_3, before tips of M_3, Cu_1, and An, and round fork of M. Membrane hairy in region of stigma. Cu_{1a} bare, moderately oblique, scarcely half as long as stem of cell M_3. Ax nearly straight, ending opposite Cu_{1a}. Halteres with yellow stem and long black knob. *Length* of body, 2·5 mm.; wing, 3·2 mm.

NORTH ISLAND: Titirangi, Auckland, 30th November, 1915 (*A. E. Brookes*); type male in British Museum.

Molophilus inornatus n. sp. (Fig. 141.)

♂. Whole body, including antennae, legs, and wings, dark brown, without markings; only coxae somewhat lighter. Antennae about as long as body. Flagellar joints elongate, bottle-shaped, necks narrow and bare; verticils irregular, about twice as long as joints; last joint blunt-ended, without neck. Abdomen with yellowish pubescence. Hypopygium with two pairs of claspers widely separated by membrane, one pair basal, elongate, longer than side-pieces, with a fringe of hair apically and a protuberance bearing bristles before middle; the other pair subapical, short, curved, blunt-tipped. Penis very long and slender. Front legs long and

slender (others missing). Venation: Ax long and straight, ending below middle of stalk of cell M_3. Cu_{1a} hairy, nearly vertical, slightly beyond fork of M. R_3 and M_1 both somewhat approximated to R_{4+5} at the tip. Length of body, 3·5 mm.; wing, 5·5 mm.

NORTH ISLAND: Hamurana, 19th November, 1919 (*D. Miller*), one male. Type in collector's possession.

Notwithstanding differences in antennal and colorational characters, this is evidently related to *M. variegatus*, the hypopygium of both having a similar and very peculiar structure.

Genus GNOPHOMYIA O.-S.

This genus as at present understood includes a considerable number of species from all parts of the world, which show a rather extensive range of structural characters. I think there can be no doubt that a division into several genera will have to be made, but the species require further study in all their stages before this can be done very satisfactorily. The two New Zealand species are very dissimilar in appearance and habits, and each shows some peculiar features distinguishing it from most, if not all, other known species. I therefore propose a new subgeneric name for each of these species. The distinctions between these and true *Gnophomyia* can best be expressed by means of the following table, which includes all the genera and subgenera some species of which have recently been included in *Gnophomyia*: some or all of them will probably eventually be accorded full generic rank.

1. Rs rather short, almost or quite in a straight line with R_{4+5}; R_{2+3} strongly arched; *r-m* at or close to the base of R_{4+5}; *r* vertical, near base of R_2; tip of R_1 long; eyes widely separated	*Gnophomyia* s. str.
Rs generally longer; not in a line with R_{4+5}; R_{2+3} not strongly arched; *r-m* well beyond base of R_{4+5} ..	2
2. R_2 very short, much less than half as long as R_3	3
R_2 longer, more than half as long as R_3	4
3. Legs covered with scales; discal cell closed	*Gymnastes* Brun.
Legs without scales, but with long pubescence; discal cell coalescent with cell M_3	*Dasymallomyia* Brun.
4. Sc_2 oblique, longer than Sc_1; *r* placed about the middle of R_{2+3}; discal cell coalescent with cell M_1; front narrow ..	*Aphrophila* n. subgen.
Sc_2 vertical, usually much shorter than Sc_1; *r* joining R_1 and R_2; discal cell closed	5
5. Head round, front very narrow; body and legs elongate; *r* oblique and longer than the tip of R_1	*Astelobia* n. subgen.
Head broader, front not very narrow; body and legs much less elongate; *r* usually vertical and shorter than the tip of R_1	6
6. An accessory cross-vein in cell R_3	*Furina* Jaen.
No such cross-vein	7
7. Body shining, black and yellow	*Psiloconopa* Zett.
Body otherwise coloured: *Gnophomyia luctuosa* O.-S., *G. elegans* Wied., *G. peramoena* Alex., *G. perelagens* Alex., *G. fascipennis* Thomson, &c. (Also genus *Trimicra*.)	

Gnophomyia s. str. includes, besides the type species, *G. ferruginea* Will., *G. tripudians* Bergr., *G. orientalis* Meig., *G. nigrescens* Edw., &c.

Dasymallomyia should perhaps include *Gnophomyia hirsuta* Alex., which has a closed discal cell. Alexander regards it as a subgenus of *Gnophomyia*, but the two species have a very different appearance from those of *Gnophomyia* s. str.

Gymnastes Brun., is regarded by Alexander, perhaps with reason, as a subgenus of *Paratropeza.*

Aphrophila and *Astelobia* are proposed respectively for *Gnophomyia neozelandica* n. sp. and *G. rufa* (Hudson); in neither case is any other species known.

Gnophomyia (Aphrophila) neozelandica n. sp. (Fig. 47.)

♀. Body short and stout, blackish, more or less dusted over with dark grey; a small shoulder-spot, an area round the wing-base, and the ovipositor ochreous. Front very narrow, about one-tenth as broad as head. Palpi and antennae black. Flagellar joints about twice as long as broad, with very short pubescence, and short verticils, shorter than joints. Ovipositor peculiar: anal valves very short, strongly curved, less than half as long as the long anal segment, which bears apically a pair of tufts of hairs; genital valves also short, not reaching apex of anal segment. Legs dark brown, coxae and femora lighter; hind tarsi as long as tibiae. Wings longer than the body, greyish-tinged, stigma sharply defined, black. Sc_2 oblique, slightly longer than Sc_1. Cross-vein *r* vertical, shorter than tip of R_1, joining R_{2+3} well before base of R_2. Discal cell confluent with cell M_1. Halteres ochreous. Length of body, 10 mm.; wing, 13 mm.; hind leg, 19 mm.

South Island: Otira Gorge, resting on boulders close to water's edge amongst the foam; Warnock's Creek (*G. V. Hudson*, No. 232). The habits suggest that the species has an aquatic larva; if this is so, it would confirm the separation of the species from *Gnophomyia.*

Gnophomyia (Astelobia) rufa (Hudson). (Fig. 48.)

Tipula rufa Hudson, *Trans. N.Z. Inst.*, vol. 27, p. 294, 1894.
Gnophomyia rufa Hutton, *Trans. N.Z. Inst.*, vol. 32, p. 39, 1900.
Gnophomyia rufa Hudson, *Trans. N.Z. Inst.*, vol. 52, p. 32, 1920.

A large and very conspicuous orange-yellow species, remarkably distinct in coloration from all other known members of the genus. The front is even narrower than in *G. neozelandica*, the thorax and abdomen both unusually elongate. Male hypopygium with only a single pair of claspers, which are, however, deeply toothed on their outer margin, and bear a small fleshy lobe at their base, which perhaps represents the second pair; penis very large, strongly chitinized, with single terminal opening. Ovipositor with anal valves moderately long and slender, nearly straight. Legs longer than in *G. neozelandica*, but hind tarsi much shorter than tibiae. Sc_2 vertical, shorter than Sc_1. Cross-vein *r* very oblique, much longer than tip of R_1, joining R_2 well beyond base. Discal cell closed. Length of body, ♂ 24 mm., ♀ 29 mm.; wing, ♂ 19 mm., ♀ 21 mm.; hind leg, ♂ 49 mm., ♀ 52 mm.

North Island: Wellington (*G. V. Hudson*, No. 60). South Island: Nelson (Hudson).

According to Hudson, the early stages are spent in semi-liquid detritus between the bases of the leaves of the epiphytic plant *Astelia Solandri.** The larva and pupa figured by him differ very markedly from those of the genotype (*G. tristissima* O.-S.), and thus support the separation of this species from *Gnophomyia* s. str.

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* *Trans. N.Z. Inst.*, vol. 52, p. 32, pl. 1, figs. 8, 9, 1920.

Genus TRIMICRA O.-S.

Osten-Sacken mentions that he has seen a species of this genus from New Zealand. There is a single specimen in the British Museum from Titirangi, Auckland, 30th December, 1915 (A. E. Brookes), which is too damaged to determine specifically; it may or may not be the cosmopolitan *T. pilipes*. If it is, it is the only species of crane-fly so far discovered in New Zealand which is not endemic to the country. (See text-fig. B.)

The terminal joints of the antennae do not seem to be quite as small as in *T. pilipes*, and are scarcely differentiated from the others.

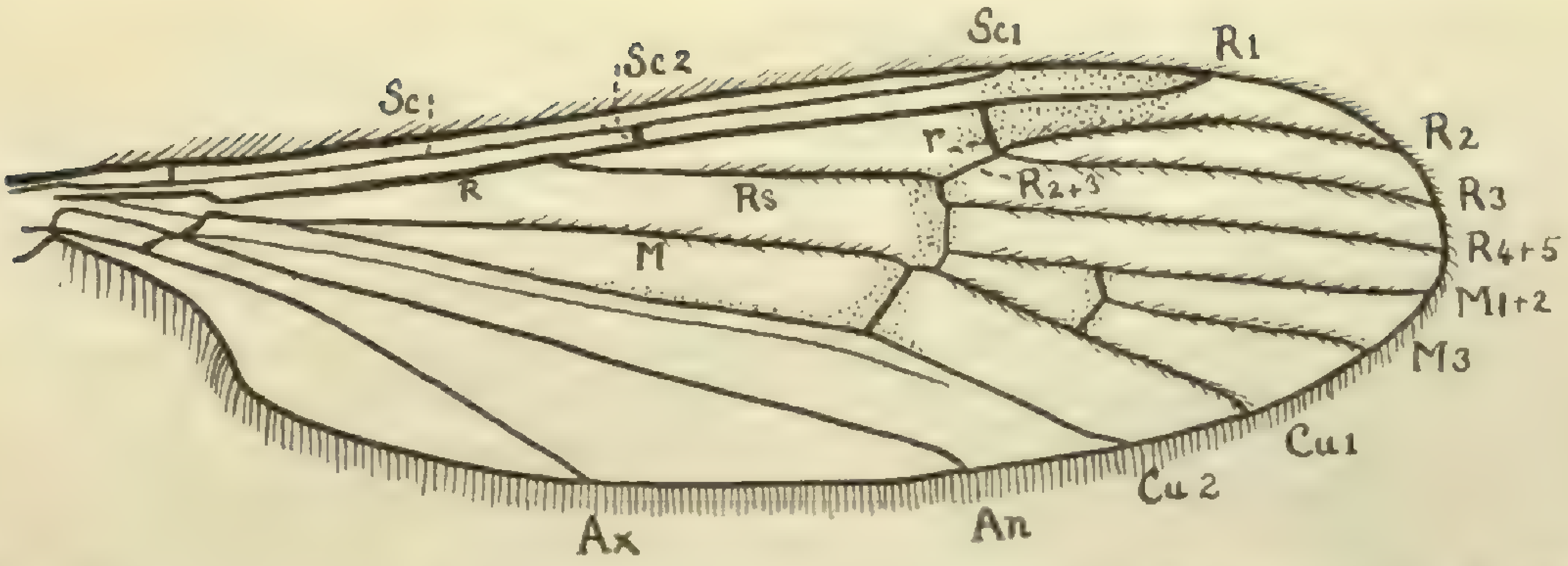
Tribe **Limnophilini.**

Leaving out of account for the moment the genera of the *Gynoplistia* group, the members of this tribe are exceedingly difficult to classify, because, although the numerous species exhibit an extensive range of structure, there are few obvious diagnostic characters on which genera can be defined. Most of the generic and subgeneric names which have been proposed have been founded on very unsatisfactory characters, many of which are certainly variable in closely related species; such characters are the presence or absence of accessory cross-veins in different positions, the spurring of Rs, and the length of the male antennae. It is very probable that the early stages will afford a much more satisfactory basis of classification than the adults, but until this has been discovered* it seems inadvisable to go much further in the subdivision of the old genus *Limnophila*.

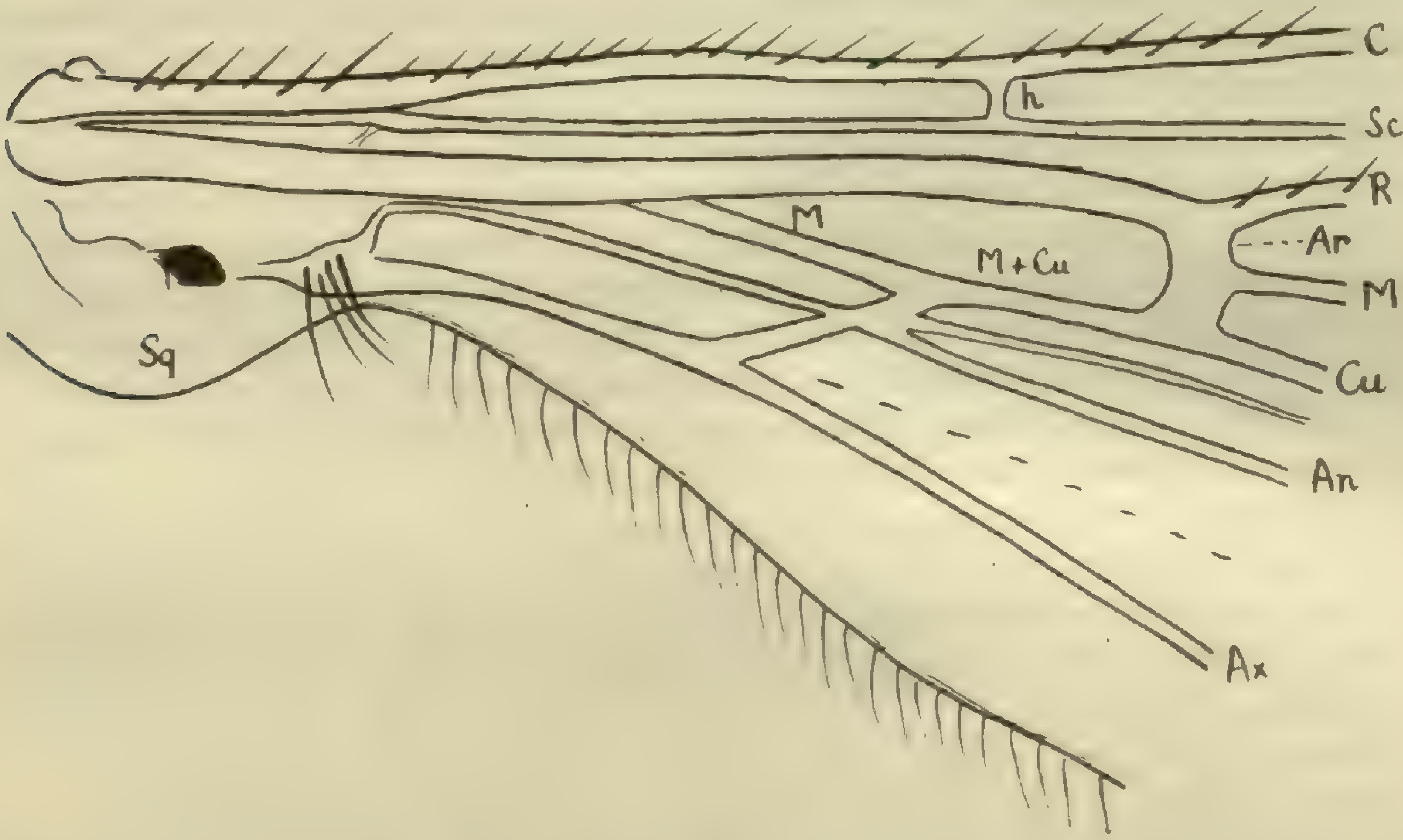
In endeavouring to discover characters which may be useful in defining the genera of this tribe in a natural manner I have found one which I believe may be of considerable value: this is the condition of the base of the median vein. In *Gynoplistia*, *Cerazodia*, *Orolimnophila*, and *Limnophila skusei* (text-fig. C) the media is connected with both R and Cu at the base; the connections with R I have spoken of in this paper as the "arcular cross-vein," although it is quite possible that is really not a true cross-vein, but the base of the media itself. This, at any rate, appears to be the interpretation which Tillyard places upon it; but it seems easier to regard as the actual base of the media the short vein which arises from R still nearer the base of the wing, and fuses with Cu for some distance before separating as the main stem of the media. This condition is found also in the great majority of Palaearctic and Nearctic Limnophilini (*Ephelia*, *Idioptera*, *Dicranophragma*, *Lasiomastix*, *Limnophila* sensu O.-S., *Prionolabis*, *Eutonia*, *Poecilostola*, *Pseudolimnophila*, *Neolimnophila*, *Pilaria*, *Adelphomyia*). On the other hand, in all the remaining Limnophilini found in New Zealand the media arises from Cu a good deal farther from the base of the wing (the above-mentioned fusion with Cu being longer) and has no connection with R at this point. I believe this is likely to be a more primitive condition, and have expressed it (perhaps wrongly) by saying that the arcular cross-vein is absent (see text-fig. D). A similar condition to this is found in *Epiphragma*, and also in *Limnophila ochracea* Mg., and in *Dactylolabis*. It is worth noting that *Epiphragma* and *L. ochracea* are wood-feeders, like the New Zealand *Rhamphophila*.

Another character which may be found to be of generic value when fully understood is the presence or absence, before the middle of most of

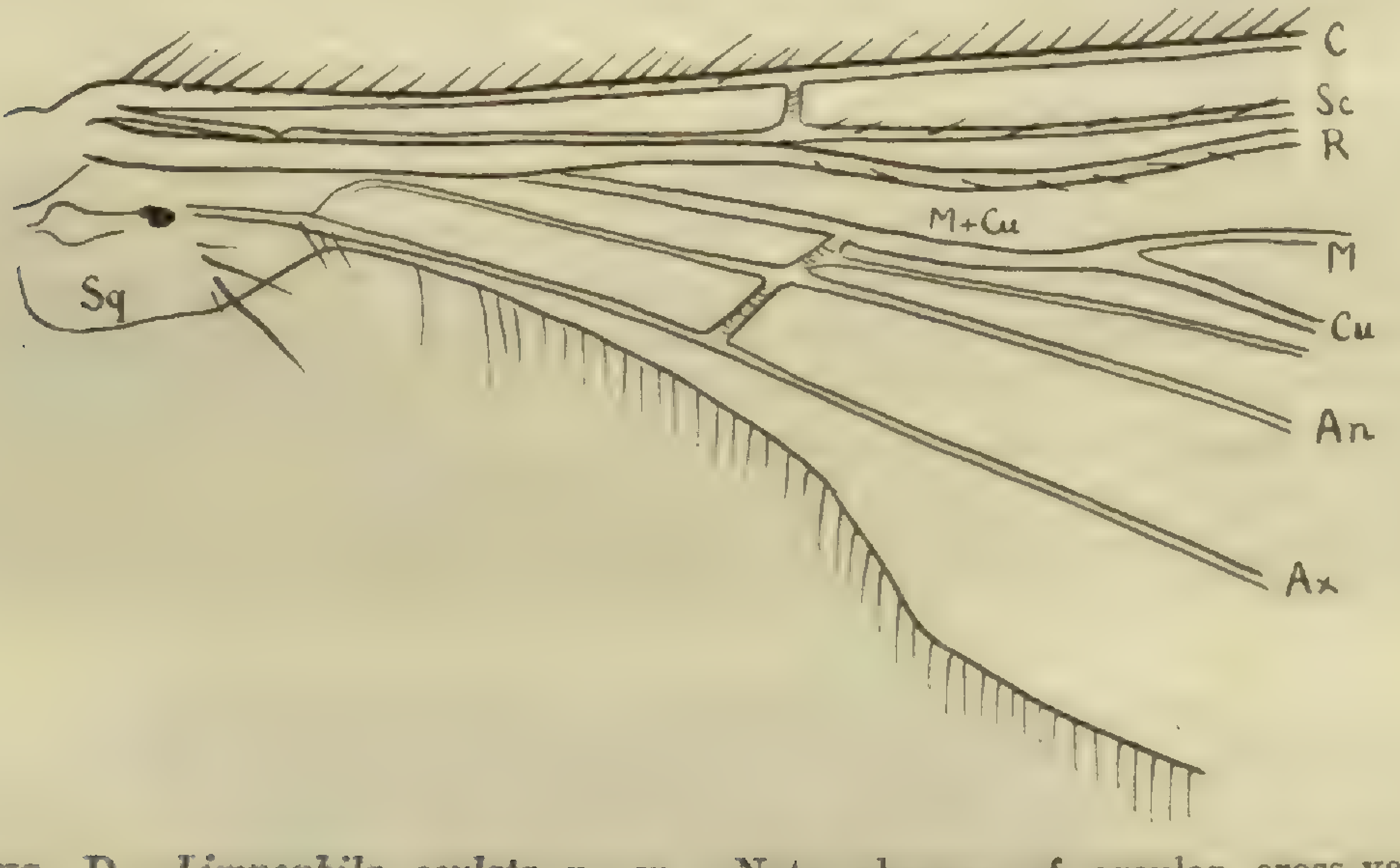
* Dr. C. P. Alexander informs me that he has attempted a classification of the Limnophilini on the larvae and pupae in the second part of his monograph on the crane-flies of New York. At the time of writing this work has not appeared in print.



TEXT-FIG. B.—*Trimicra* sp. (New Zealand specimen), to explain notation of wing-veins. The cells take the name of the vein bordering their upper margin.



TEXT-FIG. C.—*Limnophila skusei* Hutton. Base of wing, showing origin of media, A_2. arcular cross-vein. Sq = squama.



TEXT-FIG. D.—*Limnophila oculata* n. sp. Note absence of arcular cross-vein and presence of bristles on squama.

the abdominal tergites, of a pair of transverse, shining, impressed areas. These are very conspicuous in *Epiphragma*, as pointed out by Osten-Sacken, and occur in all the New Zealand species of *Limnophila* and allied genera, except *L. skusei*. This appears to be another indication of the affinity of the New Zealand Limnophilines with *Epiphragma*. Similar impressed areas occur in *Limnophila ochracea* and in *Poecilostola* and *Pseudolimnophila*.

A third point of which it may eventually be possible to make some use is the presence or absence of distinct bristles on the squama. These bristles are characteristic of one group of New Zealand species, and their presence seems to be correlated with certain characters of the venation and hypopygium.

The following is a more or less artificial key to the New Zealand genera of Limnophilini provisionally recognized in this paper :—

1. Antennae simple	2
Flagellum pectinate, or at least some of the joints enlarged beneath	7
2. Wings rudimentary in both sexes	*Zaluscodes.*
Wings fully developed in both sexes	3
3. R_2 short and joining costa a short distance beyond tip of R_1; *r* absent	*Orolimnophila.*
R_2 long, extending to nearer tip of wing; *r* present, though sometimes faint	4
4. Rostrum longer than the head	5
Rostrum at most as long as the head	6
5. Rostrum only slightly longer than head; Cu_{1a} at base of discal cell	*Rhamphophila.*
Rostrum twice as long as head and thorax together; Cu_{1a} about middle of discal cell	*Tinemyia.*
6. Wing-membrane pubescent over nearly the whole surface ..	*Ulomorpha.*
Wing-membrane bare	*Limnophila.*
7. Antennae 13–22-jointed	*Gynoplistia.*
Antennae 29–39-jointed	*Cerozodia.*

Genus ZALUSCODES Lamb.

" Wings much abbreviated, with no distinct veins. Antennae with sixteen joints. Palpi with four joints, the last orbicular and attached to the side of the small third joint. Tibial spurs present on all the legs."—(*Lamb.*)

This genus is evidently to be regarded as a *Limnophila* which has lost its wings. Lamb states that " the male genitalia appear to be somewhat as shown for *Zalusa* in Dr. Enderlein's paper," but there is really no close resemblance : *Zaluscodes* has a hypopygium of the ordinary Limnophiline type, while *Zalusa*, in this organ as in other parts of its structure, is clearly a near relative of *Dicranomyia*.

Zaluscodes aucklandicus Lamb.

Zaluscodes aucklandicus Lamb, *Subantarctic Is. N.Z.*, p. 130, 1909.

An almost uniformly brown, long-legged species, which is remarkable for having the wings of both sexes extremely reduced, much shorter than the thorax.

AUCKLAND ISLANDS : "This remarkable species was common in damp places in forest, Carnley Harbour. It runs rapidly over the ground, like a small harvestman spider. An extremely fragile insect. The colour is white when alive."—(*G. V. Hudson.*) Type male and female in Cambridge Museum.

Genus Orolimnophila Alex.

Oromyia Alexander, *Jour. N.Y. Ent. Soc.*, vol. 21, p. 203, 1913 (preocc. by *Orosmya* Rondani).

Orolimnophila Alexander, *Ent. News*, vol. 32, p. 178, 1921.

? *Lachnocera* Philippi, *Verh. z.-b. Ges. Wien*, vol. 15, p. 615, 1865.

This genus at present contains two South American species described by Alexander. The new species described below, together with the two obviously allied Australian species *Limnophila lawsonensis* Skuse and *L. australasiae* Skuse, differs from the genotype (*O. lloydi* Alex.) in the longer vein Sc; in the absence of a lyriform plate on the ninth sternite of the male; and in the extremely short tibial spurs (this at least in the New Zealand species). I had at first intended creating a new genus for these three species, but have refrained from doing so, as the second species just described by Alexander (*O. argentinicola*) seems intermediate as regards the length of Sc and the structure of the hypopygium, and has short tibial spurs. *Orolimnophila* must therefore be regarded as common to the Australasian and Neotropical regions.

It was suggested by Bergroth (*Wien. Ent. Zeit.*, vol. 9, p. 123, 1890) that *L. lawsonensis* and *L. australasiae* might belong to Philippi's genus *Lachnocera*. This opinion may eventually prove to be correct; there are certainly some strong resemblances, but Philippi's figure shows remarkably elongate scapal joints in the male antennae, whereas in *Orolomnophila* these joints are very short. A final decision on this point cannot be made until Philippi's *L. delicatula* has been rediscovered.

Orolimnophila eluta n. sp. (Figs. 49, 142.)

♂. *Head* dark grey, moderately hairy. Front about a quarter as broad as head. Palpi rather long, black. Antennae about one and a half times as long as the whole body; scape ochreous, first joint scarcely longer than second, both very short and somewhat swollen; flagellum fourteen-jointed, the joints gradually decreasing in length, all provided with dense, evenly distributed pubescence, which is about twice as long as the width of a joint, or rather more. *Thorax* uniformly ochreous, bare, slightly shining, rather short and rounded. *Abdomen* dark brown; hypopygium ochreous, constructed as in figure; outer clasper blackened, serrate on outer margin, inner one longer, pale; no trace of any appendage of ninth sternite. *Legs* slender, uniformly ochreous; tibial spurs extremely short, only about half as long as diameter of slender tibia. *Wings* slightly milky, quite unmarked, veins pale ochreous. Sc ending above apex of Rs, Sc_1 about twice as long as Sc_2. Arcular cross-vein well marked. Halteres long, pale ochreous. *Length* of body, 8·5 mm.; antennae, 12 mm.; wing, 10 mm.

South Island: Mount Arthur, 3,500 ft., January, 1920 (*G. V. Hudson*, No. 50), one male in British Museum; Otira (*G. V. Hudson*, No. 50), type male in British Museum, a second male in Cambridge Museum; Mount Grey, Canterbury, 13th April, 1917, one male in Canterbury Museum.

The specific name has allusion to the "washed-out" wings, the two Australian species of the genus both having conspicuous wing-markings.

Genus Rhamphophila n. gen.

Head rounded, not produced behind, front moderately broad, eyes contiguous beneath. Rostrum slender, somewhat longer than head, the

rather long palpi inserted at its tip. Antennae sixteen-jointed; first joint rather long; verticils sparse and moderately long. Thorax very high and narrow; tuberculate pits and pseudosutural foveae both absent. Abdomen with transverse impressed areas distinct. Male hypopygium large and complex; side-pieces produced into two or three finger-like lobes apically; two pairs of hairy claspers; a separate more or less lyriform plate on ventral side, perhaps representing the true ninth sternite; ninth tergite with small median projection; aedoeagus large and complicated, provided with two rounded lobes at tip of penis in addition to the two large parameres. Tibial spurs rather long and stout. Venation: Basal fusion of M and Cu long; arcular cross-vein absent or very faintly indicated. Sc long; Sc_1 longer than vertical Sc_2. Tip of R_1 shorter then *r*. Rs long, more or less angled at base; R_{2+3} short. Cell M_1 present. Cu_{1a} oblique, meeting M at base of discal cell. Squama without bristles.

Genotype: *Limnophila obscuripennis* Hudson (*sinistra* Hutton).

The produced rostrum, and the position and obliquity of Cu_{1a} seem sufficient to warrant the establishment of a new genus for this species. According to Alexander (*in litt.*), "it is obviously closer to *Epiphragma* then to *Limnophila*, and probably also to *Tinemyia*, which may represent the maximum development of the group. Hudson's rearing of *R. sinistra* proves that it has little in common with *Limnophila*, although close to *Epiphragma*. The immature stages of both forms are wood-dwellers, a habitat that I have to believe as being very characteristic of generalized forms."

Apart from the genotype and the new species described below, I know of no others belonging to this genus.

Rhamphophila obscuripennis (Hudson). (Figs. 51, 145, 146, 147.)

Tipula obscuripennis Hudson, *Trans. N.Z. Inst.*, vol. 27, p. 294, 1895.
Limnophila sinistra Hutton, *Trans. N.Z. Inst.*, vol. 32, p. 40, 1900; Hudson, *Trans. N.Z. Inst.*, vol. 52, p. 33, 1920.

The wing-markings of this conspicuous fly will at once distinguish it from all other New Zealand crane-flies, except *R. lyrifera*, described below; the Australian *Limnophila antiqua* Skuse has similar wing-markings, but is certainly not at all closely allied. In hypopygium, the upper apical lobe of side-piece is rather long and with a short stump dorsally some distance before tip; the lower lobe is short; ventral plate broad at base, with nearly straight lateral horns scarcely as long as the basal portion, between the horns being a small median projection. Femora have a narrow and very oblique pre-apical dark ring.

NORTH ISLAND: Auckland (*W. Wesché*); Wellington district (*G. V. Hudson*, No. 17); Te Wairoa (*D. Miller*); Papatotara, 26th February, 1911.

According to Hudson, this species "is fairly common in most dense forests throughout the country. The larva inhabits fallen tree-trunks in an advanced state of decay, forming burrows between the soft decayed portion and the harder part of the wood."

Hudson's name *obscuripennis* is preoccupied in *Limnophila*, but (in my opinion) becomes valid when transferred to a new genus. I propose to restrict the name to what is evidently the commoner of the two New Zealand species. Among the eight males I examined there was no variation in hypopygial structure.

Rhamphophila lyrifera n. sp. (Figs. 52, 148, 149.)

♂. Differs from *R. obscuripennis* as follows: Pre-apical dark ring of femora considerably broader and less oblique. Ventral plate of hypopygium lyriform, basal part narrow, no median projection. Median projection of ninth tergite longer. Main apical lobe of side-piece split to base into two nearly equal fingers.

SOUTH ISLAND: Routeburn, Lake Wakatipu (*G. V. Hudson*, No. 17N); type male in the British Museum. Mount Grey, Canterbury, November, 1917; one male in Canterbury Museum. The wing of the type (fig. 52) shows some slight differences from *R. obscuripennis*, but these are not to be seen in the second specimen.

Genus TINEMYIA Hutton.

This genus is no doubt related to *Rhamphophila*, from which it differs chiefly in its more slender build; in the much longer rostrum; in the position of Cu_{1a}; and in the different and much simpler structure of the hypopygium. Only the one species is known.

Tinemyia margaritifera Hutton. (Figs. 50, 144.)

Tinemyia margaritifera Hutton, *Trans. N.Z. Inst.*, p. 44, 1900.

This species may easily be known by the remarkably elongate rostrum, and by wing-markings, which are strongly reminiscent of those of *Epiphragma*. Little need be added to Hutton's description, except that front is very narrow, and arcular cross-vein is absent, as in the majority of New Zealand Limnophiline groups. The male resembles female except that antennae seem to be a little longer. The hypopygium is very distinctive. Side-pieces not lobed apically, but have large ventro-basal hairy lobes, and narrow transverse membranous area in middle of dorsal surface. Claspers are somewhat as in *Ulomorpha nebulosa*, the resemblance being particularly noticeable in the stiff bristles on inner side of inner clasper near tip. The parameres are long, stout, and sharp-pointed; penis simple and arched.

NORTH ISLAND: Wellington (*G. V. Hudson*, No. 139); one male in British Museum; "very rare."

Genus ULOMORPHA O.-S.

Five species of this genus are at present known, all from North America. I have some hesitation in referring two New Zealand species here, because Alexander's figure of the wing of *U. pilosella* (the genotype) shows a well-marked arcular cross-vein. Apart from this possibly fundamental difference, the New Zealand species do not exhibit any very definite character by which they can be separated generically. The fact that they both possess cell M_1 is of no particular importance, since one of the North American species also has this cell.

The two new species are most easily distinguished by the striking difference in the width of the axillary cell.

Ulomorpha nebulosa n. sp. (Figs. 53, 143.)

♂. *Head* rounded, without distinct neck, dull, rather light brown; front somewhat greyer, less than one-eighth as broad as head at its narrowest part. Palpi and rostrum short, ochreous, the latter less than half as long as head. Scape of antennae ochreous, first joint fully twice as long as

second. Flagellum rather dark brown, joints oval, slightly over twice as long as broad, verticils equalling diameter of joint. *Thorax* brownish, mesonotum slightly shining; three large confluent praescutal stripes, not much darker than ground-colour. Tuberculate pits absent. *Abdomen* slender, dark brown dorsally, hind-margins of basal tergites narrowly paler; venter much more extensively pale. Hypopygium—ninth tergite deeply bilobed. Outer claspers hairy, with bare flattened tip. Inner claspers nearly straight, somewhat spatulate at tip, with two or three long stiff hairs directed inwardly. Parameres broad and flat except at base. Penis deeply bilobed at tip. *Legs* very slender, uniformly rather dark brown, except for ochreous coxae. Tibial spurs very short, only about half as long as diameter of tip of tibia. *Wings* greyish-tinged, with rather dense macrotrichia over nearly the whole surface, except basal to origin of Rs. Five cloudy brown spots along costa — near base, at origin of Rs (the largest), and over tips of Sc, R_1, and R_2; brown clouds also over cord, apex of discal cell, base of cell M_1, and along vein R_{4+5}. Sc ending just beyond apex of Rs; Sc_2 oblique, longer than Sc_1; cell R_2 shortly stalked; Cu_{1a} before middle of discal cell; cell Ax rather broad. Two or three bristles on squama, one rather long. Halteres long; stem dark brown, apex of knob paler. *Length* of body, 9–10 mm.; wing, 10–11 mm.

North Island: In forest, Karori, Wellington, April (*G. V. Hudson*, No. 245); type and one other male in British Museum; a third male in Cambridge Museum.

Ulomorpha fuscana n. sp. (Fig. 54.)

♂. Differs from *U. nebulosa* as follows: Head dark-greyish, front fully quarter as broad as head. Palpi and antennae all black. Thorax and abdomen somewhat darker. Parameres slender, not flattened. Legs darker. Wings more strongly tinged with brownish, the dark markings smaller, no dark spot near base; Sc a little longer; Cu_{1a} nearer base of discal cell; cell Ax much narrower. Halteres all black. Length of body, 7 mm.; wing, 8·5 mm.

North Island: Karori, Wellington, amongst *Piper excelsum*, April (*G. V. Hudson*, No. 302b); type male in British Museum.

Genus Limnophila Macq.

It is perhaps unlikely that any of the sixteen species now included here will eventually be regarded as belonging to this genus, at least in the strict sense. However, it would require an exhaustive investigation into the whole group in order to arrive at a nomenclature which would express in a satisfactory manner the relationships of the different species, and this I am unable to undertake. I therefore confine myself to the suggestions made above (see under the tribe heading). So far as published subgenera are concerned, most of the New Zealand species (and also many of the Australian forms described by Skuse) would appear to approach most nearly to Alexander's groups *Austrolimnophila* and *Limnophilella*, both of which are supposed at present to be exclusively Neotropical. In neither case has Alexander stated whether or not the arcular cross-vein is present, but Bigot's coloured figure of *L.* (*Austrolimnophila*) *cutaeinata* shows it as absent (though his sketch of the venation, on the other hand, indicates it as present). Nothing has been noted concerning the impressed areas on the abdominal tergites in these subgenera, but from Alexander's description of the abdominal markings of *L.* (*Limnophilella*) *epiphragmoides* it would seem that they are most probably present.

We may probably conclude, therefore, that in *Limnophila*, as in most other genera, the New Zealand crane-fly fauna shows the strongest affinities with that of Australia, and secondly with that of South America. The species may be identified by means of the following key:—

1.	Cell M_1 absent; body all black	*bryobia* Mik.
	Cell M_1 present; body not all black	2
2.	Arcular cross-vein present; pseudosutural foveae very large; no impressed areas on abdominal tergites 3–7	*skusei* Hutton.
	Arcular cross-vein absent; pseudosutural foveae very small or absent; pairs of distinct impressed shining areas on abdominal tergites 2–7	3
3.	Wings hyaline, unmarked; Cu_{1a} at or slightly before base of discal cell	*delicatula* Hutton.
	Wings with distinct markings; Cu_{1a} near or beyond middle of discal cell	4
4.	Wings with numerous small dark dots in the cells; macrotrichia on veins in apical part of wings unusually long; side-pieces of male hypopygium produced apically into a long horny point	*leucomelas* n. sp.
	Wing-markings and hypopygium otherwise; macrotrichia of veins short	5
5.	Praescutum much swollen; femora yellow with the tips narrowly black	*subinterventa* n. sp.
	Praescutum normal; femora darker or with two dark rings..	6
6.	Squama with bristles; Sc_2 oblique and longer than Sc_1; wing-markings more or less ocellate	7
	Squama without bristles; Sc_2 vertical and generally shorter than Sc_1; wing-markings not ocellate	11
7.	Rs strongly spurred; antennae black, the first flagellar joint orange	*geographica* Hutton.
	Rs not spurred; antennae otherwise coloured	8
8.	Wings pale-brownish, with indistinct whitish rings	*crassipes* Hutton.
	Wings with light ground-colour and conspicuous dark rings ..	9
9.	Abdomen all dark	*oculatus* n. sp.
	Small yellow spots over the impressed areas of the abdominal tergites	10
10.	Cu_{1a} at middle of discal cell; an ocellate spot about middle of cell Ax	*argus* Hutton.
	Cu_{1a} near apex of discal cell; no ocellate spot in cell Ax ..	*lambi* n. sp.
11.	A dark spot or cloud about the middle of cell M	12
	No such spot present	13
12.	Sc_2 before apex of Rs	*marshalli* Hutton.
	Sc_2 much beyond apex of Rs	*chrysorrhoea* n. sp.
13.	Sc_2 level with *r-m*	*umbrosa* Hutton.
	Sc_2 beyond the level of *r-m*	14
14.	A conspicuous black vertical girdle on thorax	*nigrocincta* n. sp.
	Thorax not girdled with black	15
15.	Very large species; dark spots over bases of M and Rs reaching costa	*cyatheti* n. sp.
	Medium-sized species; costal cell clear	*hudsoni* n. sp.

The first four or five of these species occupy rather isolated positions, and might perhaps be placed in as many distinct subgenera; the remainder fall into two natural groups by the characters given above.

Limnophila bryobia Mik.

Limnophila bryobia Mik., *Verh. z.-b. Ges. Wien*, vol. 31, p. 205, 1882.

The following are the chief characters mentioned by Mik:—

♂. Body wholly black, somewhat shining, with slight brown dusting. Antennae black, as long as head and thorax together, flagellar joints elliptical. Legs black, with fairly long and dense pubescence; coxae and base of femora brown; each tibia with two strong spurs. Wings very broad,

brown-tinged; stigma elongate, fuscous, not sharply defined; veins black, except R and Cu, which are brown. Cell M_1 absent. Ax with its tip somewhat hooked, bordered with blackish for its whole length, especially towards tip. Length of body, 9 mm.; wing, 10 × 3·3 mm.

AUCKLAND ISLANDS (*Krone*). The specimen flew out from a sod of moss, the box containing which was not opened by Krone for over four years after the collection was made. Krone and Mik believe that the pupa or larva had lived in the moss for this period.

Type in the Vienna Museum (presumably).

Limnophila skusei Hutton. (Figs. 68–70, 150.)

Limnophila skusei Hutton, *Trans. N.Z. Inst.*, vol. 34, p. 190, 1902.
Limnophila novae-zelandiae Alexander, *Insecutor Inscitiae*, vol. 8, p. 121, 1920.

The wing-markings of this species are rather variable (see figs, 68–70), but form a ready means of identification, apart from the structural characters mentioned in the key. The male has not hitherto been described; it has the antennae distinctly longer than those of the female (fully twice as long as thorax), flagellar pubescence also longer, but the sexes are otherwise similar. Male hypopygium (fig. 150) remarkable for having three pairs of claspers (including a nearly globular one which is just possibly the modified tip of the side-piece), and the complicated aedoeagus, with three sets of paired appendages. There is a pair of transverse, impressed, shining areas near base of second tergite, but the remaining tergites are devoid of such areas. The tibial spurs are about as long as diameter of tip of tibia. Venation: Sc_2 short, vertical, only about a quarter as long as Sc_1. Cross-vein *r* vertical, about half as long as the nearly straight tip of R_1. Cross-vein *m* usually longer than basal part of M_3 (in other words, the lower of the two veinlets closing the discal cell is usually longer than the upper). One specimen has an accessory cross-vein present in both wings in cell R_{4+5}, placed near the base of M_1 in such a way as to make this vein appear to be a branch of R_{4+5}. There are no bristles on squamae. Length of body, ♂ 11–13 mm., ♀ 16–18 mm.; wing, 12–16 mm.

NORTH ISLAND: Wellington district, in swampy places (*G. V. Hudson*, No. 8); type female in Canterbury Museum, three males and three females in British Museum. SOUTH ISLAND: Mount Grey, Canterbury, November, 1917, one male in Canterbury Museum; Tisbury, 7th November, 1915 (*A. Philpott*), one female in Cawthron Institute collection; Otago (*Osten-Sacken*), Alexander's type female in Berlin-Dahlem Museum.

Mr. Hudson informs me that the type of *L. skusei* bears his number 8, and is undoubtedly the same as other specimens sent to me under this number. The synonymy with *L. novae-zelandiae* is therefore certain.

Limnophila delicatula Hutton. (Figs. 66, 151.)

Limnophila delicatula Hutton, *Trans. N.Z. Inst.*, vol. 32, p. 42, 1900.

An extremely distinct species on account of the hyaline wings, devoid of markings except for the pale-brownish stigma. *Head* dark grey; front narrow, not one-eighth as broad as head. Antennae alike in both sexes, a little longer than the small thorax; first scapal joint rather long, whitish-ochreous, second rounded, dark-ochreous; flagellum dark brown,

joints slender, nearly cylindrical, verticils a little longer than joints. *Thorax* brownish; praescutum and scutum somewhat shining; postnotum and pleurae heavily dusted with grey. *Abdomen* slender, with the usual impressed areas on tergites 2–7. Male hypopygium very small, constructed as in figure; the aedoeagus peculiarly complicated. *Legs* uniformly brownish, very long and slender; tibial spurs shorter than diameter of tibia. *Wings* as in figure; Cu_{1a} is either exactly at base of discal cell or a short distance before it. Sc_2 rather oblique, as long as Sc_1; *r* rather oblique, as long as tip of R_1. Rs not spurred. Squama without bristles. It is worth noting that in most specimens macrotrichia are present on Cu_{1a} as well as on both veinlets which close the discal cell. Since one at least of these must be a true cross-vein, this species forms an exception to Tillyard's rule that macrotrichia are confined to the longitudinal veins. This is by no means the only such exception which has come under my notice. *Length* of body, 9–12 mm.; wing, 9–12 mm.

North Island: Wellington district, in forest, March (*G. V. Hudson*, No. 160); two males and three females in British Museum.

This species is probably referable to the subgenus *Limnophilella* Alex., but in the two described South American species *r* is much farther from the tip of R_1.

Limnophila leucomelas n. sp. (Figs. 55, 152.)

Head rather dark brownish-grey; front nearly a quarter as broad as head. Rostrum scarcely half as long as head, blackish. Palpi black. Antennae in female about as long as head and thorax together, in male nearly twice as long; scape brownish-ochreous, the first joint moderately long; flagellum black, first six or seven joints yellow at base, joints cylindrical, verticils about as long as joints in female, shorter in male. *Thorax* with mesonotum ochreous-brown, praescutal interspaces darker brown posteriorly, a dark-brown line round margin. Pseudosutural foveae small. Pleurae with a narrow ochreous line above, then broadly dull black, this colour extending on to apex of postnotum, and including base of halteres; below the black area pleurae are almost silvery-white, and coxae similarly coloured. *Abdomen* dark brown, segments lighter apically, especially on venter. The usual impressed areas are present, but inconspicuous. Hypopygium as in figure; side-pieces with tips drawn out into long curved horns, no basal lobes; outer claspers hooked at tip; parameres very short and broad, blackened. *Legs* (except for the whitish coxae) rather dark brown, tips of femora pale, preceded by an ill-defined dark ring. *Wings* with a slight brownish tinge, and with numerous small dark-brown dots crowded over greater part of surface; larger spots at base and apex of Rs and at tips of most of veins. Macrotrichia unusually long and dense on most of veins in apical half of wing. Sc_2 vertical, shorter than Sc_1. Tip of R_1 longer than *r*. Cu_{1a} and upper of the two veinlets closing the discal cell without macrotrichia. Cu_{1a} about middle of discal cell. Halteres rather short, dark brown. *Length* of body, 6–8 mm.; wing, 8–9 mm.

North Island: Wilton's Bush, Wellington, November, 1920 (*G. V. Hudson*, No. 211); one male (type) and two females in British Museum. A third female from Karori, Wellington, November, 1912, among ferns (*G. V. Hudson*, No. 211a), differs from these in having a continuous and rather broad dark seam along Rs. The thoracic coloration is not at all unlike that of *L. geographica*.

Limnophila subinterventa n. sp. (Figs. 67, 153, 154.)

Head rather dark-brownish, dusted with whitish-grey round the eyes. Front broad, about one-third as broad as head: eyes widely separated below. Rostrum less than half as long as head. Palpi long, ochreous. Antennae about twice as long as thorax in female, as long as abdomen in male; scape brownish-ochreous, first joint short and rather broad; flagellum dark brown in male, pale ochreous in female; joints gradually decreasing in length, pubescence and verticils, as usual, longer in male than in female; hairs of the verticils more numerous in female. *Thorax* pale ochreous, dusted with whitish-grey; middle area of mesonotum darker: scutellum and postnotum (median sclerite) rather dark brown, somewhat shining, a dull black patch extending from wing-base to above front coxae, broadening out in front. Praescutum swollen, covering pronotum and extending partly over head. Tuberculate pits and pseudosutural fovae absent. *Abdomen* slender, ochreous; in male the apical halves of segments blackish; in female there are black lateral patches on tergites immediately behind impressed areas, connected by a brown shade across dorsum, hind-margins of segments being also darkened. Hypopygium as in figures; structure of penis, with a serrated area some distance behind sharply pointed tip, is rather remarkable. *Legs* ochreous, tips of femora and extreme tips of tibiae black. Tibial spurs slightly shorter than diameter of tip of tibia. *Wings* slightly yellowish-tinged, veins mostly pale; small black clouds over cross-veins and cord, bases of cells M, R_2, M_1, and M_2, and at tip of R_2. Sc_1 a little longer than vertical Sc_2; *r* vertical, a little shorter than slightly upturned tip of R_1. Discal cell unusually large. Two or three minute bristles on squama. Halteres long and slender, stem pale ochreous in female, dark in male, knob dark brown. *Length* of body, ♂ 9 mm., ♀ 11–14 mm.; wing, 9–12 mm.; antennae, ♂ 7·5 mm., ♀ 3–4 mm.

NORTH ISLAND: Kaitoke, Wellington, 14th March, 1921, type male, and Wainuiomata, Wellington, 12th February, 1921, two females, in British Museum; also one other female without exact data (*G. V. Hudson*, No. 193), and another female, in Cambridge Museum.

This species is apparently related to the Australian *L. antiqua* and *L. interventa*, which both have a gibbose praescutum. To the latter of these species *L. subinterventa* is very similar in coloration and venation, but differs in several details, such as the unicolorous antennae. It is just possible, though I think improbable, that the male and female here described are not conspecific.

Limnophila geographica Hutton. (Figs. 61, 155.)

Limnophila geographica Hutton, *Trans. N.Z. Inst.*, vol. 32, p. 43, 1900.

The specimens I have seen of this species do not correspond in every detail with Hutton's description, but I think the determination must be correct. The following characters may be noted, additional to those mentioned by Hutton: Male antennae about as long as thorax; first scapal joint rather long; first flagellar joint somewhat swollen, longer than next two joints taken together; remaining joints slender, elongate oval, verticils nearly twice as long as joints. Pleurae with a conspicuous black stripe from propleurae to base of abdomen; below this the pleurae and also coxae are heavily dusted with white. Pseudosutural foveae present, but small. Abdominal tergites 2–7 each with one pair of impressed areas about middle. Hypopygium as figured; it is remarkable for the enormous

development of the dorsal plate of the aedoeagus. There are no membranous appendages of ninth tergite, such as characterize *L. argus* and its allies. Trochanters blackish. Femora pale at extreme tip, and with a very conspicuous pale-ochreous ring some distance before tip. Base of tibiae ochreous; spurs as long as the diameter of tip. Cu_{1a} near apex of discal cell. Two bristles on squama.

NORTH ISLAND: Wilton's Bush, Wellington, in dense forest, 1st December, 1920 (*G. V. Hudson*, No. 287); one male in British Museum.

Limnophila crassipes Hutton. (Fig. 62.)

Limnophila crassipes Hutton, *Trans. N.Z. Inst.*, vol. 32, p. 41, 1900.

A single damaged specimen has been presented to the British Museum by Mr. G. V. Hudson; it shows the following characters not mentioned by Hutton: Front about one-sixth as broad as head, with small but fairly obvious tubercle. Rostrum a little over half as long as head. Antennae brown, about as long as thorax (female?), flagellar joints rather elongate oval, verticils about as long as joints. Pseudosutural foveae and tuberculate pits absent. A rather narrow but conspicuous blackish stripe across pleurae extending from just below prothoracic stigma to base of abdomen. Tibial spurs slightly longer than diameter of tibia. Wing-venation much as in *L. argus;* in one wing there is an accessory cross-vein in cell R_2 (an aberration which I have seen in many species of *Limnophila*). There are faint pale rings in all the positions occupied by the dark rings in *L. lambi.* Squama with two bristles.

NORTH ISLAND: Karori, Wellington, November, 1920, very rare (*G. V. Hudson*, No. 148A).

Limnophila oculata n. sp. (Figs. 63, 156.)

Head dark brown with slight grey mottling. Front about one-fifth as broad as head. Rostrum about half as long as head. Palpi long, dark brown. Antennae rather longer than head and thorax together; scarcely longer in male than in female, but more distinctly pubescent; colour dark brown, the first few flagellar joints narrowly ochreous at base. First scapal joint rather long; flagellar joints cylindrical, the first few somewhat stouter and rather shorter than the rest. *Thorax* rather dark brown, praescutum indistinctly striped, with grey lines along interspaces, margins darker brown; postnotum and pleurae dusted with greyish, without distinct markings. Pseudosutural foveae absent. *Abdomen* uniformly dark brown; two pairs of impressed areas on each of tergites 2–7, one close to base, the other just before middle. Hypopygium as figured: ninth tergite emerginate with a pair of fleshy, membranous appendages, sublaterally placed; parameres broad and rather flat, with a small hook on one side at tip. *Legs* rather dark brown; femora with rather distinct whitish ring some distance before tip, dark ring beyond this, extreme tips somewhat lighter, especially on under-side. No empodia. *Wings* with a slightly milky ground-colour (viewed by reflected light), except in cell M and towards tip, where it is darker; dark markings along costa and more or less ring-like dark spots at tips of nearly all veins, as in figure. Sc_2 twice as long as Sc_1, appearing as a continuation of Sc. Tip of R slightly upturned and a little longer than *r*. Three or four bristles on squama, one longer than the others. Halteres ochreous, knob darker. *Length* of body, ♂ 14 mm., ♀ 19 mm.; wing, 16 mm.

NORTH ISLAND: Karori, Wellington, in forest (*G. V. Hudson*); type male, 27th February, 1921 (No. 281), and one female, October, 1911 (No. 125K), in British Museum. This is evidently nearly allied to *L. argus*, but is perfectly distinct.

Limnophila argus Hutton. (Fig. 65.)

Limnophila argus Hutton, *Trans. N.Z. Inst.*, vol. 32, p. 41, 1900.

Distinguished at once by the very conspicuous ocellate wing-markings, the two most conspicuous eye-spots being before middle and at tip of Ax. Sc_2 is very oblique, and about twice as long as Sc_1; r about as long as tip of R_1; Cu_{1a} at middle of the discal cell; squama with two bristles, both rather strong, but one much longer than the other. Antennae alike in the two sexes, flagellar joints rather elongate oval, verticils about as long as joints. Pseudosutural foveae absent. Postnotum dull-blackish at base, shining brown apically, some ochreous dusting at edge of black area. Each of the abdominal tergites 2–7 has two pairs of transverse shining impressed areas, one close to base, the other just before middle. Male hypopygium has almost precisely the same structure as in the following species. Tibial spurs distinctly longer than diameter of tip of tibia. The empodia absent in British Museum specimen.

NORTH ISLAND: Karori, Wellington (*G. V. Hudson*, No. 125G); one female in British Museum. SOUTH ISLAND: Kennedy's Bush, 9th November, 1919, one male in Canterbury Museum; Tisbury, 15th October, 1916 (*A. Philpott*), one female in Cawthron Institute collection.

Limnophila lambi n. sp. (Figs. 64, 157.)

Differs from *L. argus* as follows: Postonotum almost uniformly brown. slightly shining. Discal cell much shorter, Cu_{1a} quite close to its tip, None of the eye-spots on the wings with definite dark centres, and no ring at all in middle of Ax, the one at tip of Ax not particularly conspicuous.

As in *L. argus*, empodia absent, and male hypopygium shows the following characters: Ninth tergite slightly emarginate, with a pair of membranous, fleshy appendages, laterally placed. Outer claspers slightly hooked at tip. Inner claspers with a long, slender, bare, cylindrical terminal portion. Side-pieces with large, almost membranous, pubescent ventro-basal lobes. Parameres broad, rather flat, with a patch of fine hairs at tip on inner side, and a rather strong hook at tip on outer side. Length of body, 10 mm.; wing, 11 mm.

NORTH ISLAND (?): Locality uncertain, but probably Wellington district (*G. V. Hudson*, No. 125); type male in British Museum. This is possibly only a variety of *L. argus*, but seems so distinct that I describe it provisionally as a separate species. The type was presented to the British Museum by my friends Dr. H. Scott and Mr. C. G. Lamb, and is one of a number of specimens sent for determination by Mr. G. V. Hudson to the latter in 1911.

Limnophila chrysorrhoea n. sp. (Figs. 58, 158.)

Head dark greenish-grey, blackish on eye-margins in front. Front about one-fifth as broad as head, slightly swollen immediately above base of antennae. Rostrum and palpi blackish, the former a little shorter than

head. Antennae alike in the two sexes, about twice as long as thorax; scape ochreous, flagellum dark brown, base of the first and tips of first three or four joints ochreous; pubescence inconspicuous, rather shorter than diameter of joints; each flagellar joint with a single long hair and one or two shorter ones; joints almost cylindrical, all but first three slightly enlarged at base. *Thorax* ochreous-brown, darker in female than in male, mostly dusted with greyish-ochreous, except round margin of praescutum, which is somewhat darker; postnotum with dark median stripe. Tuberculate pits and pseudosutural foveae absent. *Abdomen* brownish-ochreous, with narrow dark-brown lateral stripes, hind-margins of tergites narrowly pale; transverse impressed areas long and conspicuous; venter uniformly pale. Hypopygium—ninth segment forming a continuous ring, tergite with a median projection. Tips of side-pieces with rather long and dense golden hair. Claspers inserted just before tips of side-pieces, in shape resembling those of *L. cyatheti*. Side-pieces with pubescent ventro-basal lobes, somewhat as in *L. cyatheti*. There are apparently two pairs of strong parameres, though one pair might perhaps be regarded as dorso-basal lobes of the side-pieces. *Legs* rather light brown; femora with two dark-brown rings, the second one close to tip, leaving extreme tip pale, area between dark rings paler than ground-colour. Tibial spurs rather stout, as long as diameter of tibia. *Wings* brownish-tinged, with about twelve more or less light-brown spots, as in figure. Venation much as in *L. cyatheti*, but Sc_1 and R_{2+3} are rather longer, and Rs is less distinctly spurred. No bristles on squama. Halteres dark brown, tip of knob paler. *Length* of body, 11 mm.; wing, 13 mm.

North Island: Karori, Wellington, January, 1896 (*G. V. Hudson*, No. 144d, 346a); type male in British Museum. South Island: Mount Grey, 7th November, 1916; one female in Canterbury Museum.

Limnophila marshalli Hutton. (Figs. 57, 159.)

Limnophila marshalli Hutton, *Trans. N.Z. Inst.*, vol. 32, p. 42, 1900.

Differs from *L. chrysorrhoea* as follows: Median stripe of postnotum blacker, broader at base. Hypopygium with claspers rather differently shaped and inserted at tips of side-pieces, which are without dense golden hairs at tip; basal lobes of side-pieces not split; also other differences as in figure. Sc_2 farther removed from tip of Sc, placed before apex of Rs; dark spots over Sc_2 and tip of Sc_1 separate and distinct.

North Island: Wilton's Bush, Wellington (*G. V. Hudson*, No. 144).

Limnophila umbrosa Hutton.

Limnophila umbrosa Hutton, *Trans. N.Z. Inst.*, vol. 32, p. 43, 1900.

According to Hutton's description, this differs from *L. chrysorrhoea* in the following points: (1) Sc_2 is in a line with, instead of far beyond, *r-m*; (2) four or five of the spots on wings are fused, forming a semicircular fascia from base of Rs through *r-m* to tip of Sc; (3) "spots at the tips of all the longitudinal veins"; (4) Hutton does not mention a spot in middle of cell An; (5) the last five joints of flagellum are oval.

North Island: Wellington (*Hudson*).

Limnophila nigrocincta n. sp. (Fig. 59.)

♀. *Head* dark reddish-brown. Front about one-quarter as broad as head; eyes well separated below. Rostrum lighter than vertex, about

half as long as head. Palpi blackish. Antennae about as long as thorax; scape and first flagellar joint ochreous, remainder dark brown; verticils a little longer than joints; joints almost cylindrical, very slightly enlarged at base. *Thorax* rather dark brown; scutellum and angles of pronotum whitish; an ill-defined smoky area over prothoracic stigma; a distinct black girdle extending across the base of postnotum, and from thence to mesosternum. Praescutal stripes indistinct; the usual black hair present along interspaces. Tuberculate pits and pseudosutural foveae both absent. *Abdomen* dark brown, paler beneath, without definite markings, impressed areas distinct. *Legs* moderately stout; coxae ochreous, front pair marked with dark brown in front; femora ochreous, each with two sharply marked black rings, the second well before tip; tibiae and tarsi dark brown. Tibial spurs as in *L. chrysorrhoea*. *Wings* with a slight brownish tinge, a dark-brown band across the cord, and numerous sharply marked roundish dark-brown spots, as in figure. Sc_1 not much longer than Sc_2, which is nearly vertical; *r* faint, about as long as the nearly straight tip of R_1; Rs spurred at base; Cu_{1a} at middle of discal cell. Halteres brownish, middle of knob darker. *Length* of body, 11 mm.; wing, 10 mm.

NORTH ISLAND: Wainuiomata, in forest, 15th December, 1920 (*G. V. Hudson*, No. 275): type and one other female in British Museum.

Limnophila cyatheti n. sp. (Figs. 60, 160, 161.)

♂. *Head* dark reddish-brown, with slight grey dusting. Front narrow, about one-seventh as broad as head, with a small bifid tubercle above antennae. Rostrum reddish-brown, with labella about as long as head. Palpi long, dark brown. Antennae more than half as long as body; scape reddish-brown, rather stout; flagellar joints cylindrical, with rather long and dense pubescence, the last few joints also with one or two long hairs; joints gradually decreasing in length; first three or four entirely ochreous-brown, remainder darkened at base. *Thorax* rather dark reddish-brown; mesonotum slightly shining, praescutal stripes somewhat darker; pleurae grey-dusted; tuberculate pits and apparently also pseudosutural foveae absent. *Abdomen* reddish-brown, unmarked. Hypopygium—ninth tergite with a rather long and narrow square-ended median projection. Side-pieces with very large pubescent basal lobes split at base into inner leaf-like and ventral cylindrical portions. Claspers hairy basally, tips bare; tip of outer pair somewhat hooked, of inner pair hammer-shaped. Two distinct pairs of strong parameres, penis small. *Legs* moderately stout, brown, tibiae and tarsi rather darker; femora with dark-brown tips, and with indistinct dark ring some distance before tip, most obvious on hind pair. Tibial spurs rather stout, as long as diameter of tip of tibia. *Wings* tinged with pale ochreous, veins rather light brown; brown markings as in figure. Sc_1 ending much beyond base of R_2; Sc_2 almost vertical, about half as long as Sc_1; *r* oblique, longer than the short upturned tip of R_1; Rs spurred at base; cell M_1 longer than its stalk, Cu_{1a} about middle of discal cell. Basal fusion of M and Cu long; no arcular cross-vein. No bristles on squama. Halteres rather long, pale; knob elongate, darkened apically. *Length* of body, 19 mm.; antennae, 13 mm.; wing, 19 mm.

NORTH ISLAND: Wellington, forest gullies, four, 1915 (*G. V. Hudson*, No. 202); type male in British Museum; a second male in Cambridge

Museum. "A rare and handsome species, taken among tree-ferns (*Cyathea dealbata*)."

This species is the largest member of the genus at present known from New Zealand. The somewhat produced rostrum shows an approach to the genus *Rhamphophila*, to which *L. cyatheti* is probably not distantly related. The pair of long cylindrical processes on ventral side of hypopygium may represent a divided ninth sternite, or the lyriform plate of *Rhamphophila* may perhaps be formed of fused basal lobes of the side-pieces. Whichever view be taken, it is quite probable that the two structures are homologous.*

Limnophila hudsoni n. sp. (Figs. 56, 162.)

Head dull brownish-grey. Front one-sixth as broad as head. Rostrum about as long as head. Palpi rather long, blackish. Antennae alike in both sexes, about as long as head and thorax together; scape ochreous; flagellar joints slightly enlarged at base, with short pubescence and rather short verticils, all black at base and ochreous towards tip, last few joints almost all black. *Thorax* dull-brownish, mostly grey-dusted; praescutum with indistinct darker markings; pronotum and scutellum lighter. No tuberculate pits; pseudosutural foveae very small, oval, close to margin of praescutum. *Abdomen* rather dark brown. Hypopygium as in figure; ninth sternite large, extending across ventral surface, and distinctly separate from tergite at sides, at least apically. Side-pieces with pubescent basal lobes, which are emarginate but not deeply split. Apparently two pairs of large parameres, of very different form; penis large and very broad. *Legs* brown; femora with dark-brown ring close before tip, and another one, rather feebly marked, anterior to this. Tibial spurs as in *L. cyatheti*. *Wings* with ground-colour milky-white; cells C, R_3, and M, and greater part of cells M_1, M_2, M_3, and Cu_1, light brown; dark-brown markings as in figure; note that the first two spots do not reach the costa. Venation much as in *L. cyatheti*, but Sc_1 is scarcely longer than Sc_2, and the straight tip of R_1 is about as long as *r*. No bristles on squama. Halteres with pale stem, knob blackish with tip pale. *Length* of body, 10–16 mm.; wing, 12–14 mm.

North Island: Wellington district (*G. V. Hudson*, No. 200); type and one other male and two females in British Museum. South Island: Arthur's Pass, January, 1920, one female in Canterbury Museum; Tisbury, 1st February, 1918 (*A. Philpott*), one male in Cawthorn Institute collection.

In spite of the very different structure of the hypopygium, this species is obviously nearly related to *L. cyatheti*.

Genus Gynoplistia Westw.

This large and fairly homogeneous genus is confined to the Australasian region, no species being known from west of Wallace's line. The variation in the number of antennal joints between the different species is great, but each species seems to be fairly constant. In view of this variation, it seems doubtful whether the South American *Ctedonia* should be kept distinct.

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* In May, 1922, I bred a series of *Limnophila cyatheti* from pupae found in decayed wood. This pupa has very beautiful curved thoracic appendages, branched like antlers.—G. V. H.

The numerous New Zealand species already known may be distinguished in the following manner:—

1.	Mesonotum dull, more or less dusted with grey	2
	Mesonotum shining, without grey dusting	18
2.	Wings abbreviated	3
	Wings nearly or quite as long as the abdomen	5
3.	Wings shorter than the thorax	*pedestris* n. sp., ♀.
	Wings longer than the thorax	4
4.	First eleven flagellar joints with short projections	*notata* n. sp., ♀.
	First seven flagellar joints with short projections	*nebulosa* n. sp., ♀.
5.	Conspicuous dark spots at tips of R_2 and R_3	6
	These spots absent or very faint	7
6.	A small distinct dark spot in cell R just before base of Rs	*magnifica* n. sp.
	This spot absent	*notata* n. sp.
7.	Three large dark blotches on hind-margin of wing, in cells Cu_1, An, and Ax	*nebulosa* n. sp.
	Wing-markings otherwise	8
8.	Abdomen with a median dorsal dark stripe	9
	Abdomen without such stripe	10
9.	Cross-vein *r-m* present	*bona* Alex.
	Cross-vein *r-m* obliterated	*conjuncta* n. sp.
10.	Several dark dots in cell M	11
	No dark dots in cell M	12
11.	Male antennae elongate, with long branches	*sackeni* Alex.
	Male antennae shorter, with shorter branches	*wakefieldi* Westw.
12.	A small dark cloud at base of cell M_1	13
	Base of cell M_1 quite clear	14
13.	Femora dark, with a conspicuous pale ring	*arthuriana* n. sp.
	Femora lighter, pale ring inconspicuous	*canterburiana* n. sp.
14.	Eighth or seventh and eighth abdominal segments black, contrasting with remainder of abdomen	15
	Abdomen uniformly coloured	16
15.	Wing-tip conspicuously darkened	*fimbriata* Alex.
	Wing-tip not darkened	*subfasciata* Walk.
16.	Thoracic pits black	*fuscoplumbea* n. sp.
	Thoracic pits rather light brown	17
17.	Wing-tip practically clear	*glauca* n. sp.
	Wing-tip somewhat darkened	*incisa* n. sp.
18.	Thorax brown, flagellum with at least sixteen joints	19
	Thorax black, *or* flagellum with only twelve or thirteen joints	23
19.	Hind tibiae with a pale ring beyond the middle	20
	Hind tibiae without pale ring	21
20.	Abdomen metallic steel-blue	*formosa* Hutton.
	Abdomen coppery-brown	*speciosa* n. sp.
21.	Legs long and slender	*tridactyla* n. sp.
	Legs much shorter and stouter	22
22.	Lateral sclerites of postnotum normal	*cuprea* Hutton.
	Lateral sclerite of postnotum produced into a conspicuous tubercle	*tuberculata* n. sp.
23.	Hind tarsi pale in the middle	*violacea* n. sp.
	Hind tarsi all dark (or else unknown)	24
24.	Mesonotum all black, or almost so	25
	Mesonotum largely brown	29
25.	A large dark spot at base of Rs	26
	Only a minute dark spot at base of Rs	28
26.	Head dusted with grey	*nigronitida* n. sp.
	Head shining, without grey dusting	27
27.	Base of cell M_1 clear	*speighti* n. sp.
	A dark spot at base of cell M_1	*anthracina* Alex.
28.	Male antennae twenty-jointed	*fulgens* Hutton.
	Male antennae fifteen-jointed	*polita* n. sp.
29.	Tibiae with white rings	*albicinta* n. sp.
	Tibiae without white rings	30
30.	Upper half of pleurae black, lower half ochreous	*trifasciata* n. sp.
	Pleurae with unicolorous integument	*clavipes* n. sp.

Division I.

Mesonotum more or less dull and grey-dusted. Front at most one-third as broad as the head.

Gynoplistia magnifica n. sp. (Fig. 71.)

Head dull greyish-brown; proboscis reddish-tinged; palpi blackish; trace of dark median line on vertex. Antennae with scape reddish-brown, flagellum sixteen-jointed, black. In male the first eleven flagellar joints have moderately long appendages, those on joints 4–8 a little longer, the longest scarcely four times as long as joint. In female the first eight flagellar joints have short ventral projections, those on joints 2–4 about as long as joints, others shorter. *Thorax* heavily dusted with rather light grey. Praescutum in front of sensory pits with a median dark stripe, behind the pits with four dark-brown stripes, middle pair narrower than others and approximated behind. *Abdomen* dark brown, slightly shining, with scarcely any grey dusting. Hypopygium—outer clasper straight, enlarged inwardly on basal half, bifid at tip, the two points about equal; inner clasper somewhat shorter than outer, simple, with rounded tip, twisted inwards at about half its length. *Legs* rather dark brown, somewhat stouter in female than in male, with an obscurely darker ring before tip of each femur. *Wings* with a slightly milky ground-colour and conspicuous dark-brown pattern as in figure. Sc_2 very oblique, rather longer than Sc_1, and appearing almost as a continuation of Sc. Halteres with ochreous stem and somewhat darker knob. *Length* of body, ♂ 16 mm., ♀ 26 mm.; wing, ♂ 14 mm., ♀ 17·5 mm.

North Island: Wellington district (*G. V. Hudson*, No. 252). Type male in British Museum, from scrubby hill-top near Wellington, February–March, 1921; also one female from Karori, March.

Gynoplistia notata n. sp. (Fig. 72.)

Allied to *G. magnifica*, but differing in the details of the wing-markings, and in the following points: Antennae of male with an appendage on twelfth flagellar joint; in female with short projections on flagellar joints 9–11 as well as 1–8. Praescutum with three rather ill-defined dark stripes. Outer clasper of male hypopygium less deeply bifid at tip, inner clasper less twisted. Dark rings of femora apical, preceded in male by an indistinct pale ring. Wings narrower, those of female abbreviated, less than half as long as abdomen. Sc_2 shorter and less oblique. Length of body, ♂ 17 mm., ♀ 23 mm.; wing, ♂ 14 mm., ♀ 7 mm.

South Island: Bold Peak, Lake Wakatipu, 7th January, 1914, amongst logs on cleared slope, 2,500 ft. (*G. V. Hudson*, No. 308); type male and one female in British Museum.

Gynoplistia nebulosa n. sp. (Fig. 73.)

Head dark grey; proboscis reddish-tinged, palpi blackish; scape of antennae and extreme bases and tip of flagellar joints ochreous, remainder blackish. Flagellum of male sixteen-jointed, joints four or five times as long as broad, joints 1–12 each with a long appendage, the longest nearly five times as long as joint bearing it; each appendage with two or three stiff hairs. Flagellum of female fifteen-jointed, joints hardly more than twice as long as broad, the first seven with short triangular ventral

projections. *Thorax* dark brown, heavily grey-dusted on pleurae, slightly so on mesonotum, without distinct markings. *Abdomen* dark brown, slightly shining. Hypopygium practically as in *G. magnifica*. *Legs* rather long and dark brown in male, with an obscurely darker pre-apical femoral ring; much shorter and lighter in colour in female. femora stouter and with dark ring more distinct. *Wings* slightly milky, with seven brown blotches, three on anterior margin, one at tip, and three on posterior margin. Sc_2 very oblique, about as long as Sc_1. In female wings abbreviated, less than half as long as abdomen. Halteres with ochreous stem and brown knob. *Length* of body, ♂ 16 mm., ♀ 17 mm.; wing, ♂ 14 mm., ♀ 7 mm.

SOUTH ISLAND: Otira, January, 1916 (*G. V. Hudson*, No. 335). Type male in British Museum; female in Mr. Hudson's collection.

Gynoplistia pedestris n. sp.

♀. *Head* light buff-coloured, with broad brown longitudinal median stripe; palpi and antennae dark brown. First scapal joint about three times as long as broad. First nine flagellar joints narrow at base, much swollen in middle, each with pointed conical projection on under-side, nearly as long as joint; projections on joints 2-5 of flagellum slightly longer than the others; all bearing short bristles. Joints 10-11 of flagellum rather abruptly smaller than preceding joints, without ventral projection (terminal joints missing). Palpal joints all about equal in length, the second and third obliquely truncate and swollen apically. *Thorax* brownish-ochreous, with pale-grey dusting specially noticeable on scutum, scutellum, and pleurae. Praescutum with there indistinct darker stripes; transverse pits very large, reddish. Suture ill defined except in middle; scutum practically flat. *Abdomen* buff, somewhat grey-dusted; a narrow median dorsal dark line. Ovipositor long, brownish (damaged at tip). *Legs* ochreous-brown, only tips of tarsal joints darkened; tibial spurs long, black. Femora rather thick, especially on apical half. Claws simple, slightly hairy at base, about twice as long as empodia. *Wings* vestigial, shorter than thorax, but distinctly showing normal venation; colour uniformly brownish. Halteres normal, ochreous with dark knob. *Length* of body, 17 mm.; wing, 2 mm.; hind leg, 14 mm.

One female, without exact data, but probably from Canterbury (*C. M. Wakefield*, 1880); type in Oxford Museum.

Gynoplistia subfasciata Walker. (Figs. 74, 163.)

Gynoplistia subfasciata Walker, *List Dipt. Brit. Mus.*, vol. 1, p. 74, 1848; Hutton, *Trans. N.Z. Inst.*, vol. 32, p. 45, 1900.

?? *Cloniophora subfasciata* Schiner, *Reise der "Novara," Dipt.*, p. 40, 1868.

Antennal flagellum fifteen-jointed in both sexes; in male the joints are about three times as long as broad, the first eleven bearing appendages, the longest of which are nearly five times as long as joint bearing them, those on joints 1 and 11 much shorter, that on joint 11 not much longer than the joint; in female joints 1–9 only bear projections, the longest of which are about twice the length of joint; some specimens show a very short conical projection on segment 10. *Thorax* greyish-ochreous, darker in male, praescutum with three fairly distinct dark stripes, sensory pits light brownish-ocherous. *Abdomen* in both sexes ochreous, somewhat shining, without grey dusting, eighth segment blackish; hypopygium as

in fig. 163; side-pieces have very large blackened spinose basal lobes, folded back inwards. Femora have distinct yellowish subapical rings. *Wings* as in fig. 74, taken from the wing of Walker's type female; in male they are slightly darkened at tip. In single male which I have seen halteres are black except for base of stem; but in the females the whole stem is pale. *Length* of body, ♂ 12 mm., ♀ 17 mm.; wing, ♂ 10×2·5 mm., ♀ 12 mm.; hind leg, ♀ 25 mm.

North Island: Neighbourhood of Auckland (*Dr. A. Sinclair*), one male and one female; also three females, without definite locality, in Walker's original series.

It is almost certain that the specimens on which Schiner based his description of the genus *Cloniophora* must have belonged to another undescribed species; I have seen none with the exact antennal characters which he describes.

Gynoplistia glauca n. sp. (Fig. 164.)

Differs from *G. subfasciata* as follows: Appendage of eleventh flagellar joint of male antennae about twice as long as joint, sometimes also a short projection on twelfth joint. Abdomen in both sexes with more or less conspicuous bluish-grey dusting; ground-colour darker than in *G. subfasciata*, but eighth segment scarcely darker than the rest; hind-margins of segments rather indistinctly pale. Hypopygium—outer clasper with the two tips divaricate, the pointed one rather longer than the serrate one, side-pieces with a conspicuous swelling close to base, visible in dry specimen; also other differences as in figures; there is some slight variation between the four specimens examined.

North Island: Titirangi, 30th December, 1915 (*A. E. Brookes*), type male; Horopito, 8th March, 1917 (*A. E. Brookes*), one male; Wellington (*G. V. Hudson*, No. 16a), one male and two females: all these in British Museum. South Island: Mount Grey, Canterbury, 7th November, 1916; one male in Canterbury Museum.

Gynoplistia fuscoplumbea n. sp. (Fig. 165.)

♂ Differs from *G. subfasciata* as follows: Thorax darker, the mesonotum almost uniformly dark-greyish, very slightly shining, the three praescutal stripes only slightly indicated; sensory pits black. Abdomen dusted with grey. Hind femora somewhat stouter. Wings somewhat narrower (10 × 2·2 mm.). Hypopygium—outer claspers not distinctly bifid, with a small pointed projection some distance before tip; basal lobe of side-piece not spinose; also other differences as in figure.

North Island: Wellington (*G. V. Hudson*, No. 126h); type male in British Museum.

Gynoplistia incisa n. sp. (Fig. 166.)

♂. Differs from *G. subfasciata* as follows: Middle praescutal stripe obsolete, greyish. Mesonotum rather distinctly ochreous on side-margins. Abdomen dusted with grey. Wing-tip more distinctly darkened; a much more conspicuous dark cloud over Cu_{1a}; the dark cloud below An rather longer. Hypopygium—outer claspers not blackened apically, with a large pointed projection about middle; inner claspers with conspicuous notch before tip; side-pieces without distinct basal lobes; &c.

NORTH ISLAND: Wellington (*G. V. Hudson*, No. 16F); type male in British Museum.

Gynoplistia fimbriata Alexander. (Fig. 77.)

Gynoplistia fimbriata Alexander, *Insecutor Inscitiae*, vol. 8, p. 126, 1920.

The antennal flagellum was missing in Alexander's type male. It is fifteen-jointed, first twelve joints with long projections, the longest about six times as long as joint bearing them, the shortest (on joint 12) about twice as long as joint; the projections bear a few stiff hairs; outer flagellar joints are a little longer than those more basally situated. Mesonotum slightly shining, with a little greyish dusting between the darker praescutal stripes. Seventh abdominal segment black, rather strongly contrasted in colour with rest of abdomen. Ninth tergite of male hygopygium is much more pointed than usual; and the claspers are remarkable, the outer pair being very deeply bifid, the inner fork extremely long, sinuous, and pointed.

SOUTH ISLAND: Greymouth (Helms); Alexander's type in Berlin-Dahlem Museum. NORTH ISLAND: Wainuiomata, Wellington, 11th February, 1921 (*G. V. Hudson*, No. 332); one male in British Museum; also another male (*G. V. Hudson*, No. 16B).

Gynoplistia arthuriana n. sp. (Fig. 75.)

♀. *Head* dark greyish-brown, with an ash-grey central line. Palpi blackish. First joint of antennae ash-grey, remainder blackish. Flagellum with fourteen joints, the first nine with somewhat conical ventral projections, the longest of which are a little shorter than joint bearing them. *Thorax* heavily dusted with grey, more brownish on sides of mesonotum; praescutum indistinctly striped; sensory pits black. *Abdomen* rather dark brown, heavily dusted with grey, broadened considerably in middle. *Legs* rather short and stout. Femora dark brown, lighter towards base, and with a conspicuous ochreous pre-apical ring. Tibiae and tarsi rather dark brown, tips of joints black. *Wings* rather short; markings practically the same as in *G. excisa*, but there is a small distinct dark cloud over base of cell M_1, and another on hind-margin towards tip of cell Ax, which are absent in the other members of the *subfasciata* group. Halteres ochreous, the knob somewhat darker. *Length* of body, 14 mm.; wing, 9·5 mm.; hind leg, 19 mm.

SOUTH ISLAND: Arthur's Pass, 3,000 ft., 7th February, 1920 (*G. V. Hudson*, No. 126); type female in British Museum. This is just possibly the female of *G. incisa*, but is more probably distinct.

Gynoplistia canterburiana n. sp. (Fig. 76.)

♀. Differs from *G. arthuriana* as follows: First few flagellar joints conspicuously pale at base, the ninth without a distinct projection (tip of flagellum beyond ninth joint missing). Mesonotum without distinct markings, sensory pits brown. Legs paler and rather more slender, the pale ring less conspicuous. Wings relatively longer; dark blotch in cell Ax more conspicuous. *Length* of body, 14·5 mm.; wing, 11·5 mm.; hind leg, 24 mm.

SOUTH ISLAND: Mount Grey, Canterbury, 28th December, 1916; type female in Canterbury Museum.

Gynoplistia wakefieldi Westwood. (Fig. 81.)

Gynoplistia wakefieldi Westwood, *Trans. Ent. Soc.*, p. 372, 1881.

As shown in Westwood's figures, flagellum fourteen-jointed in both sexes, joints 1–11 in male with rather short projections, the longest about three times as long as joints; in female joints 1–9 have short projections, the longest scarcely longer than joints. Sensory pits black. Hypopygium practically the same as in *G. sackeni*. Wings somewhat narrower than in *G. sackeni*, but with similar markings; the one figured was abnormal in having no dark cloud at base of cell M_1.

Locality unknown; probably South Island. I have examined Westwood's type male and female in Oxford Museum, also a male and female from Osten-Sacken's collection in Berlin-Dahlem Museum.

Gynoplistia sackeni Alexander. (Fig. 80.)

Gynoplistia sackeni Alexander, *Insecutor Inscitiae*, vol. 8, p. 125, 1920.

This species is chiefly remarkable for the length and slenderness of the male antennae, the whole organ being nearly twice as long as head and thorax together, the flagellar joints becoming longer towards apex of antenna, where they are about five times as long as broad. The flagellum is fifteen-jointed, of which all but the last two bear long slender projections; the longest projections are about five times as long as joints, but that on joint 13 is not much longer than joint. Wing somewhat longer and broader than that of *G. wakefieldi*, but has similar markings. Abdomen more slender than in *G. wakefieldi*, and side-pieces of hypopygium are somewhat longer, but structure of claspers is practically identical.

North Island: Wellington (*G. V. Hudson*, No. 126d); one male in British Museum compared with Alexander's type in Berlin-Dahlem Museum.

Gynoplistia conjuncta n. sp. (Fig. 82.)

Head dark grey with some obscure dark-brown markings. Proboscis and first joint of antennae dark grey; palpi and rest of antennae black. Flagellum fourteen-jointed in both sexes; in male the first nine joints bearing projections, the longest being scarcely three times as long as joints; in female the first eight joints only with projections, the longest of which are about as long as joints. *Thorax* dark grey, heavily dusted; pleurae with an ochreous tinge; praescutum with four blackish stripes, not very sharply defined; sensory pits dark brown. *Abdomen* dark grey, heavily dusted, hind-margins of tergites narrowly ochreous; a dark-brown median dorsal line, broadest in middle of each tergite, and narrowly interrupted at sutures; hypopygium and ovipositor also ochreous. Hypopygium—ninth tergite with short black transverse ridge in middle of posterior margin. Outer clasper blackened and somewhat swollen apically, tip slightly bifid, a small tooth on outer margin some distance before tip. Inner claspers simple, nearly straight. Side-pieces with a blackened but not spinose basal lobe (hardly visible externally). *Legs* shorter in female than in male; dark brown; femora somewhat lighter towards base, without distinct ring at or before tip. *Wings* with a faint milky tinge; abbreviated in female; stigma dark brown; base, Rs, cord, outer margin of discal cell, and base of cell M_1 very narrowly bordered with blackish; a dark cloud occupying basal half of cell Cu. Veins R_1, R_2, R_3, and Ax

(except tip) pale, the rest darker. Cross-vein *r-m* obliterated by contact of R_{4+5} with upper margin of discal cell. Halteres ochreous, knob somewhat darkened. *Length* of body, 13 mm.; wing, ♂ 11·5 mm., ♀ 9 mm.

SOUTH ISLAND: In river-bed, Dart River, Kinloch, Lake Wakatipu, 1st–10th January, 1921 (*G. V. Hudson*, No. 243); three males (including type) and one female in British Museum.

Gynoplistia bona Alexander. (Fig. 83.)

Gynoplistia bona Alexander, *Insecutor Inscitiae*, vol. 8, p. 123, 1920.

This is nearly related to *G. conjuncta*, but the wing-markings differ (see figure); a short *r-m* cross-vein is present; praescutum has only three indistinct brown stripes; the median dorsal line of abdomen is uniformly narrow and continuous, and there is indication of a similar line on venter; hypopygium, though similar in structure to that of *G. conjuncta*, is black.

Locality unknown.

DIVISION II.

Mesonotum shining, without grey dusting. Front usually quite half as broad as the head.

Gynoplistia tridactyla n. sp. (Figs. 78, 167.)

Head mostly shining blackish-brown, nape ochreous, a small dull-ochreous area above each antenna. Front about one-third as broad as head. Proboscis, basal joint of palpi, and scape of antenna ochreous, rest of palpi and antennae black. Flagellum of male with eighteen joints; joints 1–13 about twice as long as broad, with very long projections, the longest being about ten times as long as joint bearing it; the projections finely pubescent but devoid of longer stiff hairs; fourteenth joint with a projection which is about four times as long as joint; fifteenth joint with a short projection, shorter than joint; joints 16–18 simple, oval, somewhat stouter than preceding joints. Flagellum of female with seventeen joints, the last one apparently formed by the fusion of two; first ten joints with long projections, the longest of which are nearly four times as long as joints, most of them being dorsal. *Thorax* reddish-brown; mesonotum brightly shining; plurae dusted with whitish, a dull-blackish area immediately in front of root of wings. *Abdomen* shining reddish-brown; eighth segment darker; hypopygium and ovipositor ochreous. Hypopygium with tips of side-pieces produced into two long points which are bent inwards, and appear at first sight to be a third pair of claspers. Base of side-pieces with a deeply bifid lobe, between the forks of which passes the simple paramere. Both pairs of claspers long, simple, somewhat twisted. *Legs* brown; tarsi and tips of femora and tibiae blackish. *Wings* hyaline; tip conspicuously darkened; a large squarish blotch over base of Rs; a conspicuous fascia across cord, leaving centre of the discal cell clear. Halteres entirely ochreous. *Length* of body, ♂ 9 mm., ♀ 14–14 mm.; wing, ♂ 9 mm., ♀ 11–13 mm.

NORTH ISLAND: Neighbourhood of Auckland, 1854 (*Colonel Bolton*), one male and one female; also one male (type) and one female from Captain F. W. Hutton, locality unknown, in British Museum; Auckland (*K. Suter*), one female in Berlin Museum.

Gynoplistia speciosa n. sp. (Fig. 79.)

♀. *Head* shining dark brown, almost black between eyes; proboscis lighter; palpi dark brown. Front about one-third as broad as head. Scape and first few flagellar joints of antennae reddish-brown, remainder blackish. Flagellum eighteen-jointed, the first nine joints each with an appendage which is nearly four times as long as joint; most of these are dorsal in position, owing to twisting of antenna (as is usual in males of this genus, but not in females). Tenth flagellar joint with a rather shorter appendage, eleventh with a very short one. *Thorax* dark reddish-brown, mesonotum rather brightly shining, without markings, pleurae with grey dusting which appears almost silvery when seen from above. *Abdomen* shining dark brown, with faint coppery tint. Anal valves of ovipositor moderately slender. *Legs* dark brown, femora moderately stout (especially hind pair), ochreous on basal third or half; hind tibiae with conspicuous but ill-defined whitish ring beyond middle. *Wings* with faintly brownish-tinged ground-colour; venation and dark-brown markings as in figure. Sc_2 oblique, equal in length to Sc_1. Halteres ochreous, knob not darkened. *Length* of body, 18 mm.; wing, 15 mm.

North Island: Wellington (*G. V. Hudson*, No. 16d); type female in British Museum.

This is possibly only a variety of *G. tridactyla;* it is also just possible that it may be the female of *G. formosa.*.

Gynoplistia formosa Hutton.

Gynoplistia formosa Hutton, *Trans. N.Z. Inst.*, vol. 32, p. 46, 1900.

"Abdomen metallic steel-blue, with purple reflections. Head and antennae dark brown. Thorax dark bronze. Legs dark brown, the femora (except the tips) and a distal ring on the hind tibiae yellow. Halteres yellow. Wings faintly tinged with yellow; a large dark spot at the origin of the second longitudinal vein, and a still larger one from the costa through the bases of the second submarginal and first posterior cells to the discal, which is clear, except the inner and outer margins. A lighter spot in the upper margin of the auxiliary cell, about two-thirds from the base, and touching the sixth longitudinal vein. The antennae in the male are 22-jointed, of which 3 to 17 are branched; the last joint is small. *Length*, ♂ 12 mm.; wing, ♂ 11 mm. The female is unknown."—(*Hutton.*)

North Island: Kaitoke (*Hudson*).

Gynoplistia cuprea Hutton. (Figs. 84, 85.)

Gynoplistia cuprea Hutton, *Trans. N.Z. Inst.*, vol. 32, p. 46, 1900.

Antennal flagellum eighteen-jointed in male; sixteen-jointed in the only complete female I have seen, though in this specimen the terminal joint is nearly as long as the three preceding, and is probably compounded of three fused joints. The first fourteen flagellar joints in male, the first twelve in female, bear branches. In male the longest branches are about eight times, in female about three times, as long as joints. The hypopygium has outer claspers simple, nearly cylindrical, with slender, blackened, hooked tip; side-pieces with basal tubercle on ventral side; parameres simple, pointed, black. Colour of thorax, abdomen, and legs normally shining coppery-brown, with metallic reflections on abdomen, but some specimens are much darker, abdomen metallic violet, femora and tibiae with blackened tips. A male of this form is normal in structure. Wings

have a more or less pronounced yellow tint; the dark markings vary in intensity. The insect is of a stouter build than most other New Zealand species.

NORTH ISLAND: Wellington (*G. V. Hudson*, No. 29); in forest, Porirua, 9th December, 1920 (*G. V. Hudson*). SOUTH ISLAND: Canterbury (*Hutton*).

Gynoplistia tuberculata n. sp.

♀. *Head* shining brownish-orange. Palpi dark brown. Antennae brownish-ochreous, the pectinations black. First and ninth flagellar joints with very small conical projections beneath, second to eighth each with a cylindrical process, the longest being little more than twice as long as joint bearing it; remaining antennal joints simple. *Thorax* brownish-orange, mesonotum shining, upper part of pleurae with a patch of golden pollen; a blackish line between mesonotum and pleurae. Lateral sclerite of postnotum produced into a conspicuous tubercle, the tip of which is rounded and curved backwards. *Abdomen* shorter than wing, brownish-orange with slight coppery reflection, darker at extreme base; segments 3–6 very broad, quite twice as broad as basal segment. *Legs* missing (coxae and trochanters concolorous with thorax). *Wings* with a strongly marked yellow ground-colour, tip scarcely perceptibly darkened, but the darkening, such as it is, reaching almost to cord; an ill-defined dark cloud over cord, extending right across wing, but leaving centre of discal cell yellow; the dark colour spreading out for some distance along hind-margin towards base, and for a much greater distance up cell Cu; a dark cloud over base of Rs, reaching across cell R. Sc_1 bent sharply up to costa at tip; Sc_2 twice as long as Sc_1, but only slightly oblique. Rs square and slightly spurred at base; R_2 straight, not quite three times as long as R_{2+3}, and in a straight line with it; R_3 and R_{4+5} also straight. Ax with a strong double curve. Halteres yellowish. *Length* of body, 11 mm.; wing, 10·5 mm.

A single female in H. Loew's collection in Berlin Zoological Museum, without definite data.

Though superficially very much like *G. cuprea*, this species is really very distinct on account of the remarkable postnotal tubercles, also by the rudimentary appendages of the first and ninth antennal joints, and the straight branches of the radius.

Gynoplistia violacea n. sp. (Figs. 86, 168.)

♂. *Head* shining purplish-black, with some pale pubescence. Palpi and antennae black. Flagellum sixteen-jointed, joints for the most part less than twice as long as broad, the last few rather longer; all but the last three joints bear branches, the longest of which are quite ten times as long as joints; branch of thirteenth joint not much longer than joint. *Thorax* shining greenish-black; sides of pronotum and the greater part of the pleurae heavily dusted with dull grey. *Abdomen* shining dark violet-blue. Hypopygium tinged with ochreous, its structure as in figure; outer clasper not at all blackened, with cylindrical stem and flat tip; parameres deeply bifid, with two sharp divergent points. *Legs*: Coxae violet-black, the front and middle pair grey-dusted; trochanters dark brown; femora moderately stout, ochreous on basal two-thirds, apical third black; tibiae and tarsi black, hind tarsi brownish-ochreous except at base and tip. *Wings* slightly brownish-tinged, with ill-defined markings

as in figure. R_2 shorter and straighter than usual. Accessory cross-veins are present in both wings in cells R_1 and R_3, in different positions in the two wings. Halteres pale ochreous, the base of stem dark. *Length* of body, 9 mm.; wing, 9 mm.

South Island: Otira Gorge, December, 1908 (*G. V. Hudson*, No. 234a); type male in British Museum.

Gynoplistia nigronitida n. sp. (Fig. 87.)

♂. *Head* black, somewhat shining, but conspicuously dusted with grey. Antennae and palpi black. Flagellum with fourteen joints, for the most part about three times as long as broad, the last four shorter, terminal joint very small, globular; first nine joints bearing branches, of which the longest are about six times as long as joints; branch of ninth scarcely three times as long as joint. *Thorax* shining black; pleurae with slight grey dusting. *Abdomen* missing. *Legs* rather short and stout, femora swollen apically. Front and middle coxae dark brown; hind coxae black. Femora, tibiae, and first three tarsal joints dark reddish-brown with black tips; terminal tarsal joints black. (Hind legs missing.) *Wings* somewhat unusually broad, with well-defined blackish markings as in figure. Halteres entirely blackish. *Length* of wing, 7 mm.

South Island: Otira Gorge, December, 1908 (*G. V. Hudson*, No. 237a); type male (damaged) in British Museum.

Gynoplistia speighti n. sp.

♀. *Head* shining black, with some black hair. Palpi black. Scape of antennae brown: flagellum black, the first seven joints with basal projections, the longest of which are scarcely as long as joints bearing them; all joints scarcely twice as long as broad; joints 8 and 9 simple; terminal joints missing. *Thorax* shining blackish-brown, ochreous-tinged on shoulders, above roots of wings, and on margin of scutellum. Pleurae with a moderately large patch of fine, dense whitish pubescence. *Abdomen* shining blue-black; ovipositor yellowish; anal valves slender, nearly straight, twice as long as last segment. *Legs* rather long and slender, femora slightly thickened apically; brownish-ochreous, femora and tibiae gradually darkened towards tips, tarsi blackish. *Wings* with venation and markings practically as in *G. nigronitida*, but Cu_{1a} is a little before middle of discal cell, the dark markings are somewhat smaller, and wings rather longer in proportion. Halteres with ochreous stem and blackish knob. *Length* of body, 10·5 mm.; wing, 9 mm.

South Island: Mount Grey, Canterbury, 24th December, 1916; type female in Canterbury Museum.

Although it is evidently closely allied to *G. nigronitida*, I feel sure this cannot be the female of that species, on account of its distinctly longer and more slender legs, shining head, and whitish pleural pubescence. The specimen was among a number lent by Mr. Speight, of the Canterbury Museum, to Dr. C. P. Alexander, and through him to the writer.

Gynoplistia anthracina Alexander.

? *Gynoplistia anthracina* Alexander, *Insecutor Inscitiae*, vol. 8, p. 128, 1920.

Head and thorax entirely shining black, except that pleurae have a narrow elongate patch of extremely fine white pubescence. Middle legs slender, but wlth femora somewhat clubbed; pubescence rather longer

than in most species, that on the tibia nearly twice as long as diameter of joint; first tarsal joint is a little more than half as long as tibia (in *G. speighti* and *G. nigronitida* it is almost exactly half as long). The other legs and the wings of the type are now lost; according to Alexander's description, the wing-markings are somewhat similar to those of *G. speighti* and *G. nigronitida*, but there is a small spot at the base of cell M_1 and a complete fascia across the wing from base of Rs to hind-margin. *Length* of body, 5·8 mm.; wing, 6 mm.

SOUTH ISLAND: Greymouth (Helms); type female (fragment) in Berlin-Dahlem Museum.

Gynoplistia fulgens Hutton.

Gynoplistia fulgens Hutton, *Trans. N.Z. Inst.*, vol. 32, p. 47, 1900.

"Abdomen metallic steel-blue, with purple reflections. Head and antennae dark-brown. Thorax black, shining. Halteres yellow. Legs blackish-brown, proximal portions of the femora yellowish-brown. Wings clear, except at bases, where they are slightly tinged with yellow; a rather pale-brown spot at apex of marginal cell, extending across base of second submarginal. Only a minute spot at origin of second longitudinal vein. Discal cell open. Antennae in the male twenty-jointed, of which 3 to 15 are branched. *Length*, ♂ 13 mm.; wing, ♂ 12 mm. Female unknown."—(*Hutton*).

SOUTH ISLAND: Mount Arthur, 3,600 ft., 6th February, 1898 (*Hudson*).

Gynoplistia polita n. sp. (Figs. 88, 171.)

♂. *Head* shining black, with some black hair; palpi and antennae black. Flagellum only thirteen-jointed, joints as in *G. clavipes*. *Thorax* shining black, with scanty pale hair; pleurae with rather large patch of fine dense greyish pubescence. *Abdomen* shining, dark steel-blue; pubescence pale; side-pieces of hypopygium ochreous, with dark spot on outer side. Structure of hypopygium somewhat resembling that of *G. violacea*, but flat apical portion of outer clasper longer and more pointed; apical lobes of side-piece larger; parameres less deeply forked, &c. *Legs* rather slender; femora thickened apically, but not conspicuously clubbed. Coxae and trochanters shining black; femora ochreous on basal half, gradually shading to black apically; tibiae dark brown; tarsi black. *Wings* hyaline, tip not at all darkened; a squarish spot over base of Rs and a blackish fascia from stigma to discal cell. Halteres uniformly brownish-ochreous. *Length* of body, 5·5 mm.; wing, 6·5 mm.

SOUTH ISLAND: Mount Aurum, 3,000 ft., 17th January, 1920, (*G. V. Hudson*, No. 217B); type male in British Museum.

Apparently resembles *G. fulgens* in coloration, but is much smaller, and has fewer joints in antennae.

Gynoplistia trifasciata n. sp. (Figs. 89, 170.)

♂. *Head* between the eyes shining dark brown, with violet reflections; back part rather light ochreous. Palpi dark brown. Scape of antennae and rachis of first two flagellar joints ochreous, the rest black. Flagellum with only twelve joints, which are mostly about three times as long as broad, the last three a little shorter; the first eight bear branches, the longest of which are about eight times as long as joint bearing them, that on the eighth about five times as long as joint. *Thorax* entirely brightly

shining. Mesonotum reddish-ochreous; scutellum and base of postnotum darker. Upper half of pleurae black, the lower half pale ochreous. *Abdomen* blackish, shining, with strong violet reflections. Hypopygium (see figure) with peculiarly lobed side-pieces; outer clasper slender, cylindrical, without flattened projection at tip; parameres long, simple, tip pointed and bent. *Legs* slender, femora conspicuously clubbed on apical fourth; coxae and trochanters light ochreous; femora ochreous with black clubs; tibiae ochreous at base, gradually shading to black at tip; tarsi black. *Wings* hyaline, with small dark spot in base of cell R and three complete dark fasciae, as in figure. Halteres with slender dark stem and large black knob. *Length* of body, 4·5 mm.; wing, 5·5 mm.

North Island: Wainuiomata, Wellington, 14th December, 1920 (*G. V. Hudson*, No. 327); type and one other male in British Museum.

This species and *G. clavipes* are doubtless closely allied in spite of some striking differences. They and *G. polita* are remarkable for the reduction in the number of antennal joints, but there can be no question of removing them from the genus *Gynoplistia*.

Gynoplistia clavipes n. sp. (Figs. 90, 169.)

♂. *Head* shining black, with a little black hair. Palpi blackish. Scape of antennae and rachis of first few flagellar joints light brown, the rest dark brown. Flagellum with only thirteen joints, which are about three times as long as broad, the last three rather shorter; the first eight flagellar joints bear branches, of which the longest are about ten times as long as joint bearing them; that on the eighth is about five times as long as joint. *Thorax* rather dark brown, brightly shining, mesonotum somewhat darker, with metallic reflections; pleurae with a small patch of fine, dense, silvery-white pubescence. *Abdomen* dark brown, with strong violet reflections; hypopygium lighter, its structure as in figure: somewhat resembling that of *G. violacea*, but the dorso-apical lobe of the side-piece is longer, rounded, and bare; paramere long, nearly straight, and not bifid, &c. *Legs* slender, but the femora conspicuously clubbed on their apical fourth; coxae, trochanters, and bases of femora ochreous, the rest dark brown. *Wings* almost hyaline, with moderately dark-brown markings as in figure. Ax more sinuous than usual. Halteres ochreous, the knob somewhat darkened. *Length* of body, 7 mm.; wing, 6·3 mm.

North Island: Wellington, 6th February, 1916 (*G. V. Hudson*, No. 98a); type male in British Museum.

Gynoplistia albicincta n. sp. (Fig. 91.)

♀. *Head* shining black, the front broad, about half as broad as head. Palpi with first joint blackish, the rest light brown. Antennae dark brown. Flagellum with only eleven joints (complete, not broken); the first two joints simple, shortly oval; the next five joints somewhat longer, with a pointed ventral projection which has the whole length of joint, not not only its proximal portion, for its base; last four joints simple, the terminal joint longer than any one of the preceding three, which are nearly globular. *Thorax* shining dark brown, black posteriorly; plurae without grey dusting or dense pubescence. *Abdomen* shining black; ovipositor brown, anal valves slender almost straight, half as long again as last segment. *Legs* short and stout, with longer pubescence than in any other species known to me; on the tibiae it is about twice as long as diameter of tibiae. Femora strongly clubbed on outer third. Coxae, trochanters,

basal three-fourths of femora, and a narrow ring at base of tibiae ochreous; a rather broad whitish ring just beyond middle of tibiae; remainder of legs black (hind legs missing). *Wings* greyish-tinged, darker towards tip and towards bases of cells Cu; a small dark spot over base of Rs and a large dark-brown patch over cord. Rs shorter and more curved than in any other New Zealand species; R_2 almost straight at base; cross-vein *r* apparently absent. Halteres blackish. *Length* of body, 6·5 mm.; wing, 6·5 mm.

NORTH ISLAND: Wainuiomata, Wellington, 14th December, 1920 (*G. V. Hudson*, No. 334); type female in British Museum.

The peculiarities of this species are probably sufficient for it to be made the type of a new genus, but until the male is known it had better be regarded as an aberrant *Gynoplistia*.

Genus CEROZODIA Westw.

As already noticed by Osten-Sacken, this genus is very closely allied to *Gynoplistia* and to the South American *Ctedonia*, and it is by no means impossible that the three will some day be united. Some species of *Gynoplistia* (especially *G. magnifica*) approach *Cerozodia* in the long vein Sc_2; others (such as *G. speciosa*) in the number of joints on the antennae, while in this last point *Ctedonia* is intermediate between *Gynoplistia* and *Cerozodia*. The male hypopygium of the New Zealand species of *Cerozodia* is very similar in structure to that of *G. magnifica;* all four *Cerozodiae* are remarkably alike in this organ, and I doubt if the small differences I have observed between different specimens are of any value for distinguishing the species; I have therefore not described them. *C. pulverulenta* is possibly only a variety of *C. paradisea*, and both are just possibly only varieties of *C. plumosa*, but *C. hudsoni* is certainly a good species. The number of simple joints at the tip of the male antenna seems more or less constant for the species, but the principal characters relied on for separating them are those of the wing-markings.

Apart from the New Zealand forms, only one species of the genus has been described, *C. interrupta* Westw., from Western Australia. Dr. C. P. Alexander informs me that he has seen two species from Tasmania.

Cerozodia plumosa Osten-Sacken. (Fig. 92.)

Cerozodia plumosa Osten-Sacken, *Berlin. ent. Zeitschr.*, vol. 31, p. 213, 1887.

The antennae of Osten-Sacken's type (which I have examined) have 2 + 3 + 32 + 2 joints, as stated by the describer: "two basal ones, three remose joints, the branches of which are directed downwards, thirty-two joints with the branches directed upwards (the branch of the thirty-second is a mere stump); the last two joints have no branches, the last being rather elongate." Thorax and abdomen reddish-brown, without distinct grey dusting, thorax devoid of markings, abdominal tergites with blackish lateral line. Wings are somewhat shorter in proportion to their breadth than in the other species, and have all veins more or less distinctly bordered with brown, the border of vein Cu being particularly broad for the whole length of vein in cells M and Cu_1. There is a small dark-brown spot in base of cell R, a very small one over base of Rs, and a moderately large cloud below the dark-brown stigma. Basal section of R_{4+5} strongly curved, about six times as long as *r-m*; cell M_1 not longer than its stem; Cu_{1a}

rather more oblique than usual, meeting discal cell a little beyond the middle. *Length* of body, 24 mm.; wing, 20 × 5·5 mm.

Type in Berlin-Dahlem Museum; locality unknown.

A male in Canterbury Museum from Lake Kanieri, 17th February, 1920, is almost certainly the same species, but has the antennal formula 2 + 3 + 23 + 2; the spot over base of Rs is rather larger, and there are small dark cloudings at each angle of discal cell, which is open on one wing. Both specimens agree in having a small brown cloud on inner edge of anal angle, which is absent in *C. paradisea* and *C. pulverulenta.*

Cerozodia paradisea n. sp. (Fig. 93.)

Antennal formula 2 + 3 + 23 + 1. Thorax reddish-brown, with some grey dusting, outlining four praescutal stripes; pleurae more distinctly grey-dusted. Abdomen reddish-brown, slightly shining, without grey dusting; lateral stripe indistinct. *Legs* uniformly reddish-brown, as in *C. plumosa;* tibial spurs brown with black tips. Wings with a distinct ochreous tinge, with brown markings in base of cell R, over base of Rs, and below stigma, similar to those of *C. plumosa*, but larger; there is in addition a long dark spot in middle of cell Cu, joined to a smaller dark spot in cell An; hind-margin of wing somewhat darkened, especially in cell Ax; veins are all rather light-coloured, and are not distinctly bordered with brown. Rs spurred at base; basal section of R_{4+5} about six times as long as *r-m*; cell M_1 half as long again as stalk; upper of the two veins closing the discal cell rather shorter than lower; Cu_{1a} joining discal cell a little beyond middle. *Length* of body, 24 mm.; wing, 22·5 × 5·7 mm.

South Island: Paradise, 15th March, 1910 (*G. H. Howes*); type male in British Museum. A second male from the same locality, same date (*Dr. G. B. Longstaff*) is in Oxford Museum.

Another male in British Museum from *Nothofagus* forest, Lake Wakatipu, 2,000 ft., 9th January, 1921 (*G. V. Hudson*, No. 138), is certainly the same species, but differs in having more joints in antennae (2 + 3 + 26 + 1 on one antenna, 2 + 3 + 27 + 1 on the other); Rs is not spurred; basal section of R_{4+5} only twice as long as *r-m;* cell M_1 twice as long as its stalk; dark cloud in cell Cu longer. Two more males in Cambridge Museum from Humbolt Range, 4,000 ft. (*G. V. Hudson*, No. 138), practically agree with this one; antennal formulae 2 + 3 + 26 + 1 and 2 + 3 + 28 + 1.

Cerozodia pulverulenta n. sp. (Fig. 94.)

Antennal formula 2 + 3 + 25 + 1. Thorax darker than in *C. plumosa* or *C. paradisea*, and more heavily dusted, the four praescutal stripes fairly distinct. Abdomen brownish, without reddish tinge, slightly but distinctly dusted with grey. Tips of tibiae distinctly darkened, spurs all black. *Wings* greyish, without ochreous tinge; veins darker than in *C. paradisea*, for the most part without brown seams. A small dark-brown streak in base of cell R; whole of Rs seamed with dark brown, connecting with the dark-brown patch below the stigma; cell R_{4+5} clear except at extreme base; a small brown patch in middle of cell Cu; hind-margin of wing slightly and uniformly darkened. Rs not spurred, basal section of R_{4+5} about twice as long as *r-m*; cell M_1 as long as its stalk; upper of the two veins closing the discal cell strongly curved, rather longer than the lower, Cu_{1a} joining discal cell in or slightly before middle. *Length* of body, 23 mm.; wing, 20·5 × 5 mm.

SOUTH ISLAND: West Plains, Invercargill (*G. V. Hudson*, No. 225A); type male in British Museum. West Plains, 20th November, 1902 (*A. Philpott*); one male in Cawthron Institute collection with wing-markings exactly as in type, but antennal formula 2 + 3 + 29 + 2.

A third male, in British Museum, from Mount Aurum, Wakatipu district, 3,000 ft., 17th January, 1921 (*G. V. Hudson*, No. 361B), differs as follows: Antennal formula 2 + 3 + 26 + 1. A broad blackish-brown streak running from base of cell R to middle of cell R_3, its lower edge straight except for a slight enlargement over *r-m*; wing-tip somewhat darkened. Basal section of R_{4+5} about five times as long as *r-m*. This may be called *C. pulverulenta* var. *striata*; I do not think it can represent a distinct species.

Cerozodia hudsoni n. sp. (Fig. 95.)

♂. Antennal formula 2 + 3 + 25 + 3; centres of flagellar joints darkened (more so than in the other species). *Thorax* blackish-brown, with some grey dusting on pleurae and between praescutal stripes, which are not darker than ground-colour. *Abdomen* stouter than in the other species, shining blackish-brown, without darker lateral stripes, and without a trace of grey dusting, except on first tergite. Ninth tergite with a rather deeper emargination than in the other species, but otherwise the structure of hypopygium is very similar. *Legs* uniformly dark brown, tibial spurs blackened apically. *Wings* with an almost uniform greyish-ochreous tinge; costal cell and stigma scarcely darker; narrow clear streaks along centres of basal cells, the upper one crossing into the discal. Cell M_1 just sessile on one wing, with a very short stalk on the other. Cu_{1a} joining the discal cell just before its apex. *Length* of body, 21 mm.; wing, 17 × 5 mm.; front leg, 37 mm.

♀. Coloration of body as in male. Flagellum of antennae entirely blackened, with twenty-four joints; the first fifteen with short ventral projections, the longest of which are scarcely longer than joints; remaining joints (except the more elongate terminal one) slightly enlarged ventrally. Abdomen very broad in middle. Anal valves of ovipositor stout, curved, half as long again as long terminal segment. Legs much shorter and stouter than in male and with somewhat longer pubescence; front femora much thickened on outer two-thirds. Wings a little shorter than thorax; venation atrophied, except for costa and R_1. Halteres normal, darker in colour than in male. Length of body, 23 mm.; wing, 3 mm.; front leg, 22·5 mm.

NORTH ISLAND: Wainuiomata, Wellington, beaten from tree-ferns, 11th February, 1921 (*G. V. Hudson*, No. 147); type male in British Museum, allotype female in Mr. Hudson's collection. A second male in British Museum (*G. V. Hudson*, No. 147D) is rather lighter in colour, and cell M has a longer stem; the wing of this specimen is figured.

Subfamily TIPULINAE.

It has been customary to divide this subfamily into three tribes—Dolichopezini, Tipulini, and Ctenophorini—but the distinctions between at least the first two of these are so unsatisfactory that I can see no justification for their retention. No representatives of the Ctenophorini nor of the genus *Tipula* (in its present extent) have yet been discovered in New Zealand.

Key to the New Zealand Genera.

1. Vein R_2 and discal cell absent, Cu_{1a} joining M far before the fork .. *Dolichopeza.*
   Vein R_2 and discal cell present; Cu_{1a} joining M beyond (rarely exactly at) the fork 2
2. Vein R_3 curved, the convexity facing downwards; male hypopygium with the anal segment largely chitinized; female with conspicuous chitinous ovipositor .. .. *Holorusia.*
   Vein R_3 straight, or bent somewhat downwards towards the tip; male hypopygium usually without any chitinization of the anal segment 3
3. First few flagellar joints swollen and nearly bare, the remainder slender, with long dense hairs; abdomen elongate; female with long chitinous ovipositor; vein R_2 (in New Zealand species only) about as long as and almost in a straight line with R_{2+3} .. .. *Longurio.*
   Terminal flagellar joints not conspicuously more hairy than the rest; abdomen usually short; vein R_2 shorter than R_{2+3} and making a distinct angle with it 4
4. Antennae with twelve or thirteen joints, the last few sometimes indistinctly separated; male hypopygium small and usually twisted to one side; female ovipositor short and fleshy .. .. *Macromastix.*
   Antennae extremely short, with ten joints (male) or seven joints (female), male hypopygium large, not displaced; female ovipositor long and strongly chitinized .. .. *Hudsonia.*

Genus Dolichopeza Curt.

A small and fairly well defined genus, of almost world-wide distribution. The species are all very similar in general appearance, the most conspicuous differences being shown in the coloration of the legs.

The two New Zealand species are distinguishable at once by their size.

Dolichopeza parvicauda n. sp. (Fig. 96.)

Head greyish-brown, more ochreous above antennae; a blackish mark adjoining each eye. Front one-third as broad as head in male, a little broader in female. Rostrum ochreous, less than half as long as head. Palpi light brown. Antennae of male nearly as long as abdomen, of female not longer than thorax; scape ochreous, flagellum dark brown. In male flagellum is covered with a fine, uniform pubescence, as long as diameter of joints, and with scattered long hairs; in female the pubescence is much shorter, especially on upper side, but the hairs are quite as long and rather more numerous. First flagellar joint in male not much longer than second; in female proportionately longer. *Thorax* light brownish-ochreous, pleurae and postnotum somewhat dusted with grey. Praescutum with three dark-brown stripes, the lateral pair turned down in front. Mesepisternum with two dark-brown spots, one above the other. *Abdomen* blackish-brown, each segment with a basal ochreous band, narrowed in middle, and in female strongly dusted over with grey. Hypopygium of male very small, narrower than seventh segment; ninth tergite with lateral angles slightly produced; two pairs of hairy claspers, both shorter than side-pieces, outer pair serrate on inner ventral margin, inner pair narrower than the outer and somewhat twisted. Ovipositor normal. *Legs* almost uniformly dark brown; coxae and trochanters ochreous; a very narrow whitish ring embracing the femoro-tibial articulation. *Wings* brownish-tinged; indistinct pale areas before and beyond the blackish stigma; most of the veins slightly seamed with dark brown. Rs very short, almost perpendicular, in a line with basal section of R_{4+5} and with *r-m*, and scarcely longer than either of these. Halteres with dark-brown stem; base of knob black, tip whitish. *Length* of body, ♂ 7·5 mm., ♀ 9 mm.; wing, ♂ 8 mm., ♀ 10 mm.

NORTH ISLAND: Wilton's Bush, Wellington, in forest, 11th December, 1920 (*G. V. Hudson*, No. 185); type and one other male and one female in British Museum.

This comes very close to *D. planidigitalis* Skuse in coloration, but the hypopygium is very different.

Dolichopeza atropos (Hudson).

Tipula atropos Hudson, *Trans. N.Z. Inst.*, vol. 27, p. 295, 1895.

Dolichopeza atropos Hutton, *Trans. N.Z. Inst.*, vol. 32, p. 24, 1900.

"Uniform dark brown, the wings tinted yellowish-brown; the stigma and veins brown. The third joint of the antennae is elongated, and is as long as the fourth and fifth taken together. Second posterior cell rather short, petiolate; chief cross-vein more than half its length distant from the end of the fourth posterior cell. The auxiliary vein joins the first longitudinal at the origin of the second longitudinal. The first longitudinal ends free, and there is no marginal cross-vein. The third longitudinal is much bent down, and then turns slightly upwards before joining the margin of the wing. Anal angle of the wing distinct. Male: Length of body, 12 mm.; of wing, 15 mm. The male forceps is incrassate."—(*Hutton.*)

NORTH ISLAND: Terawhiti, Wellington, in a gold-mining shaft (*G. V. Hudson*); type male (unique) in Mr. Hudson's collection. Evidently a true *Dolichopeza*, distinct from *D. parvicauda*.

Genus HOLORUSIA Lw.

As understood at the present day, this genus is considered to be confined to South America. Two Australian species have indeed been referred by Skuse to *Holorusia*, but one of these (*H. conspicabilis* Skuse) really belongs to the related but apparently distinct Oriental genus *Ctenacroscelis*; the other (*Tipula lateralis* Walker) may be a true *Tipula*, but the type is too much damaged for generic determination. I do not consider, however, that Skuse's genus *Ischnotoma*, with three Australian species, is well separated from *Holorusia*, and the latter should therefore probably be regarded as common to the Neotropical and Australasian regions. The distinctness of the Holarctic *Prionocera* is questionable.

The two New Zealand species differ from those of South America, and agree with *Ischnotoma serricornis* in the strongly curved vein M_3; on the other hand, they agree better in antennal structure with the South American species than with *I. serricornis*, though it may be noted that the male of *H. novarae* approaches *I. serricornis* in having the flagellar joints somewhat enlarged on the under-side. The presence of a vein-stump in cell M in both *H. novarae* and *H. fulva* is noteworthy, but it is unlikely that this feature indicates any close relationship with *Macromastix maori*, which possesses a similar stump.

Hutton has pointed out that in both the New Zealand species *r-m* is placed exactly at the apex of Rs; but this is not quite constant, as I have seen specimens of *H. novarae* in which R_{4+5} has a basal section almost equalling *r-m* in length.

Holorusia novarae (Schiner). (Figs. 97, 98.)

Tipula novarae Schiner, *Reise der "Novara," Dipt.*, p. 37, 1868; Hutton, *Trans. N.Z. Inst.*, vol. 32, p. 26, 1900.

Tipula senex Butler, *Voy. "Erebus" and "Terror," Ins.*, p. 27, 1875; Kirby, *Trans. Ent. Soc. Lond.*, p. 270, 1874.

A common species, readily distinguishable by the wing-markings, which show only a slight variation. The vein-stump in cell M varies in

development; it is very rarely entirely absent or forms a complete cross-vein (one wing of one specimen in each case).

NORTH ISLAND: Auckland (*Sinclair*); Wellington (*Hudson*); Weraroa (*Miller*). SOUTH ISLAND: Mount Grey (*Canterbury Museum*); Waikouaiti (*British Museum*). Occurs throughout New Zealand, according to Hutton.

Holorusia fulva (Hutton). (Fig. 99.)

Tipula fulva Hutton, *Trans. N.Z. Inst.*, vol. 32, p. 26, 1900.

This is closely allied to *H. novarae*, differing principally in having the whole apex of the wing rather conspicuously darkened. A slight difference in the male hypopygium supports the specific distinction. The flagellar joints of the male antennae are not perceptibly enlarged beneath.

NORTH ISLAND: Wainuiomata, Wellington, in dense forest, 11th February, 1921 (*G. V. Hudson*, No. 154). SOUTH ISLAND: Nelson (*Hudson*); White Rock, 26th October, 1920 (*Canterbury Museum*).

Genus LONGURIO Lw.

The differences between *Longurio* Lw., *Acracantha* Skuse, *Aeshnasoma* Johnson, and *Austrotipula* Alex. appear to me too trivial to be treated as generic, and I therefore propose to include all four in the genus *Longurio*. Thus understood, the genus is still a very small one, but with representatives in all the chief regions of the world except Europe and Madagascar. All the species appear to be rare. In antennal structure the New Zealand species are more like the Formosan *L. rubriceps* Edw., and the Chinese *L. fulvus* Edw., than the Australian species, but the reverse is the case in regard to venation; the nearest ally, however, appears to be the North American *L. rivertonensis* (Johnson).

Longurio dux (Hudson). (Fig. 100.)

Tipula dux Hudson, *Trans. N.Z. Inst.*, vol. 27, p. 293, 1894.
Pachyrhina hudsoni Hutton, *Trans. N.Z. Inst.*, vol. 32, p. 24, 1900.
Austrotipula hudsoni Alexander, *Insecutor Inscitiae*, vol. 8, p. 129, 1920.

In this species, the giant among New Zealand crane-flies, the wings are strongly and almost uniformly brown-tinged, the veins distinctly paler than the ground-colour; cell M_1 is broadly sessile; the femora have a slightly darker pre-apical ring, the tip being conspicuously whitish.

NORTH ISLAND: Wellington (*Hudson*). I have examined two males and three females in British Museum, one male and one female in Cambridge Museum, and one female from Berlin-Dahlem Museum. I consider that Hudson's name *dux* may be revived for this species, as, although it is preoccupied in *Tipula*, it is not so in *Longurio*.

Longurio legatus n. sp. (Fig. 101.)

Wing-membrane not quite so dark as in *L. dux*, but veins conspicuously darker than ground-colour; cell M_1 only just sessile, or even provided with a very short stalk; femora uniformly brown, tip scarcely paler.

SOUTH ISLAND: Shores of Lake Wakatipu (*G. V. Hudson*, No. 141); type male and one female in British Museum; a second male in Cambridge Museum.

The slight differences from *L. dux* are constant. The hypopygia are practically identical.

Genus MACROMASTIX Osten-Sacken.

This genus is certainly related to *Tipula*, but is readily distinguishable therefrom by the absence of distinct verticils of hairs at the bases of the flagellar joints, the simple male hypopygium in which the anal segment is almost entirely membranous, and the fleshy and generally very short ovipositor of the female. These characters suggest that it may represent the ancestral type of the Tipulini, and in accordance with this it is interesting to notice that many species show a marked approach to the Dolichopezini in their very elongate tarsi and short and nearly vertical vein R_2. Indeed, the range of the characters shown by the New Zealand species is such as to make it extremely doubtful whether the sections Dolichopezini and Tipulini can be maintained as distinct. Perhaps any attempt to classify the Tipulinae into sections would be most satisfactorily based on the male hypopygium; in this respect *Macromastix*, *Hudsonia*, and *Longurio* are all similar, and possibly might all be referred to the Dolichopezini, as already foreshadowed by Skuse. In classifying the Tipulinae a great deal of stress was laid by Osten-Sacken and Skuse on the presence or absence of a nasus at the tip of the rostrum, while Enderlein has recently erected the genus *Icriomastax* for a species with a forked nasus. The study of the very extensive New Zealand material before me has proved that these characters are absolutely worthless for generic separation. The nasus may be simple or forked, present or absent, in two obviously closely allied species, in the sexes of the same species, or even perhaps in individuals of one sex of the same species. I think it probable that *Phymatopsis* Skuse, *Icriomastax* Enderlein, and perhaps *Pehlkea* Enderlein, will eventually be ranked as synonyms of *Macromastix*. I have not, however, seen specimens of any of these genera.

It may be noted further that some species of this genus have Sc_1 present, and that the fourth palpal joint is often rather short, so that the distinctions between the Tipulinae and Limnobiinae as given by Osten-Sacken are not very well maintained. A more satisfactory characterization of the two subfamilies is one based on the condition of the cubital vein.

The genus *Macromastix* seems to be highly characteristic of the New Zealand fauna; seventeen species have previously been described (some under *Tipula*), and twenty new ones are now added. If one or two of these species prove to be ill founded, others will certainly be discovered to increase the number. The range of structure between the extreme forms is very considerable, and it is possible to recognize some well-marked groups of nearly allied species, but I feel convinced that no satisfactory generic division can be made. The most distinct groups are (*a*) the eight species placed first in the sequel, which have a long praefurca (Rs) and a rather distinct facies; and (*b*) the four species showing green coloration, two of which (and probably the others also) have females with rather long and pointed ovipositors. Two characters which are very conspicuous in some species, elongation of the male antennae or reduction in width of the cell Ax, are of specific value only and do not necessarily indicate affinity.

Apart from the numerous New Zealand species, about a dozen species of *Macromastix* are known from Australia, and three or four from South America. Walker's *Tipula filigera*, supposed to be from the United States, is also certainly a *Macromastix*, the type male in the British Museum being in fairly good condition.

The following is an attempt to tabulate the New Zealand species on obvious characters applicable to both sexes:—

1.	Wings grey, with numerous cloudy whitish blotches and spots	*nebulosa* (Hudson).
	Wings otherwise	1A.
1A.	Rs long, its base scarcely beyond the middle of the wing ..	2
	Rs shorter, its base much beyond the middle of the wing ..	9
2.	Abdomen with a pale central stripe	*tenera* (Hutton).
	Abdomen with a black central stripe	3
3.	A dark cloud at the wing-tip	*clara* (Kirby).
	Wing-tip clear	4
4.	Wing-veins and membrane mostly ochreous	*orion* (Hudson).
	Wing-veins dark brown, membrane hyaline or brownish ..	5
5.	A black stripe from prothoracic stigma to mesosternum ..	6
	No such stripe	8
6.	Costal cell and stigma light brown	*auroatra* n. sp.
	Costal cell and stigma blackish brown	7
7.	Legs very short	*brevitarsis* n. sp.
	Legs much longer and more slender	*dux* (Kirby).
8.	Cross-vein *r* absent	*aperta* n. sp.
	Cross-vein *r* present	*ferruginosa* n. sp.
9.	Body at least partly green or greenish	10
	No green tinge on any part	13
10.	Thorax all green	*holochlora* (Now.).
	Mesonotum partly brown	11
11.	Lateral praescutal stripes outlined only	*virescens* n. sp.
	Lateral praescutal stripes distinct	12
12.	Costal cell light, stigma greenish	*viridis* (Walk.).
	Costal cell dark brown, stigma whitish	*albistigma* n. sp.
13.	A dark spot or patch at tip of Ax	14
	No such marking	15
14.	A vein-stump on M in middle of cell M	*maori* Alex.
	No vein-stump on M	*binotata* Hutton.
15.	Wings with conspicuous pale markings on a dark ground ..	16
	Wings without conspicuous pale markings	22
16.	Abdomen with grey dusting on certain segments only ..	17
	Abdomen without differential grey markings	19
17.	Wing-tip all dark	*lunata* Hutton.
	Cell M_1 largely pale	18
18.	Humeral and pre-arcular cells pale	*variegata* n. sp.
	Humeral and pre-arcular cells dark	*decorata* n. sp.
19.	Cell M_1 conspicuously pale	*huttoni* n. sp.
	Cell M_1 not conspicuously pale	20
20.	Cell Ax very narrow	*vittata* n. sp.
	Cell Ax broad	21
21.	Pale wing-markings large and well defined	*alexanderi* n. sp.
	Pale wing-markings smaller, less defined, and more separated	*fumibasis* n. sp.
22.	Scutellum bright orange	*fucata* Hutton.
	Scutellum dark	23
23.	Thorax and abdomen uniformly ash-grey	*cinerea* n. sp.
	Coloration otherwise	24
24.	Thoracic hair long and conspicuous	25
	Thoracic hair short and inconspicuous	29
25.	Cell Ax broad	26
	Cell Ax very narrow, especially in the male	28
26.	Four distinct praescutal stripes	*vulpina* (Hutton).
	Only three praescutal stripes	27
27.	Wings smoky, especially towards base and costa	*montana* (Hutton).
	Wings hyaline except for the stigma	*submontana* n. sp.
28.	Thoracic hair black	*minor* n. sp.
	Thoracic hair yellowish	*rufiventris* n. sp.
29.	Cu_{1a} clouded, joining discal cell at the base	*cubitalis* n. sp.
	Cu_{1a} clear, joining discal cell well beyond the base	30
30.	Abdomen long and slender, male antennae elongate ..	*pallida* Hutton.
	Abdomen not unusually long; male antennae not elongate ..	31
31.	Abdominal tergites with blackish apical bands	32
	Abdomen generally with continuous black dorsal stripe ..	33
32.	A pale patch on Cu before the fork	*obliqua* n. sp.
	Cu all dark	*incerta* n. sp.

33.	A clear spot on each side of stigma in male wing; female with rudimentary wings	*zeylandiae* Alex.
	Clear spots on each side of stigma scarcely perceptible; female wings normal	34
34.	Cell Ax very narrow; middle praescutal stripe paler than the lateral ones	*dichroithorax* Alex.
	Cell Ax broader; praescutal stripes all of the same colour ..	35
35.	Middle praescutal stripe undivided	*sinclairi* n. sp.
	Middle praescutal stripe divided by a pale line	*obscuripennis* Kirby.

DIVISION I.

Rs quite half as long again as R_{2+3}. Male antennae never elongate.

Macromastix nebulosa (Hudson).

Tipula nebulosa Hudson, *Ent. Mo. Mag.*, vol. 56, p. 276, 1920.

"♂. Expanse of wings 2 in. Length of body ⅝ in. General colour dull brown; there are two broad and two narrow longitudinal darker-brown bands on the praescutum; the prominent portions of the scutum and postnotum are also dark brown. The base of the abdomen is dull yellowish-brown, the remainder suffused with blackish-brown. Legs dark brown, darker towards the extremities. The wings are of full average width, *grey, with numerous cloudy whitish blotches and spots,* forming very irregular broken transverse bands; the first band is situated just beyond the basal cross-vein; the second, which is much the widest, beyond the middle of the wing immediately before the submarginal cells; the third band, which is very irregular and composed of numerous rather small spots, is situated on the apical and marginal areas. The halteres are long, pale yellowish-brown. The whole insect is covered with very fine pubescence. The female is unknown, but, being a winter species, may possibly be semi-apterous."—(*Hudson.*)

NORTH ISLAND: Open hills south of Wellington, 18th August, 1914 (*G. V. Hudson*).

I am indebted to Mr. G. V. Hudson for the loan of the type of this interesting species. I find it to be closely allied to *M. maori* Alex., having the same peculiar grey and cream-coloured wings, with the same short stump on the middle of vein M, and a very similar structure of the hypopygium. It differs conspicuously from *M. maori* in the wing-markings, which are as described by Hudson, and are not at all ocelliform as they are in *M. maori*. The markings are not quite symmetrical on the two wings: the large pale blotch beyond the middle of cell M extends across the anal cells on the right wing but not on the left. Alexander did not describe the antennal flagellum of *M. maori;* in *M. nebulosa* it is short, distinctly ten-jointed, the joints gradually and slightly diminishing in length towards the tip.

Macromastix tenera (Hutton).

Tipula tenera Hutton, *Trans. N.Z. Inst.*, vol. 32, p. 29, 1900.

A remarkably distinct species, the dorsal and lateral stripes being pale, with black stripes between them, which is a reversal of the usual type of coloration of the abdomen. Colour of mesonotum very variable. One male in series before me has broad deep-black praescutal stripes, as described by Hutton; a second has the stripes dark brown, in the others they are light brown, while in the females they are hardly perceptible. The ochreous colour of pleurae is not affected, nor does the structure of

hypopygium vary. The antennae are rather differently constructed from those of the other species of this group: the flagellum is distinctly ten-jointed, the joints all about equal in length, very gradually and slightly decreasing in thickness, the terminal joints not more hairy than the rest. The nasus varies in development. The female legs are shorter, but not any stouter, than those of the male.

North Island: Wellington district (*G. V. Hudson*, No. 165). The British Museum possesses three males and three females from Wainuiomata, 3rd December, 1898, and 14th December, 1920; the Cambridge Museum has two males.

Macromastix clara (Kirby). (Fig. 103.)

Tipula clara Kirby, *Trans. Ent. Soc. Lond.*, p. 271, 1884; Hutton, *Trans. N.Z. Inst.*, vol. 32, p. 29, 1900.

A very well marked species, distinguishable at once from all others by the uniformly ochreous thorax and the conspicuous brown tips of wings. The antennal flagellum is eleven-jointed, the joints all approximately equal in length, the last three more slender than the rest and with longer hairs. The legs are long and slender. The sexes are very much alike; Kirby's type is a female, not a male.

North Island: Wellington (*G. V. Hudson*, No. 142h); one male in British Museum; two males in Cambridge Museum. Auckland? (*Dr. A. Sinclair*), Kirby's type female.

Macromastix orion (Hudson).

Tipula orion Hudson, *Trans. N.Z. Inst.*, vol. 27, p. 294, 1895; Hutton, *Trans. N.Z. Inst.*, vol. 32, p. 29, 1900.

A very distinct and easily recognized species, owing to the orange-yellow veins and membrane of wings; C, Sc, R, and R_1 are black, as is continuation of costa all round margin of wing. Hutton mentions dark thoracic stripes, but these are not present in the single example I have seen, though the mesonotum is somewhat darker than the uniformly orange pleurae. Abdomen mainly orange, with a rather narrow median black stripe of even width. Coxae orange; front trochanters almost entirely orange-yellow, middle and hind pairs orange above, black below.

South Island: Mount Peel, Nelson, 4,000 ft. (*G. V. Hudson*). There is a male in British Museum, presented by Captain F. W. Hutton, and another in Cambridge Museum.

Macromastix auroatra n. sp.

♂. *Head* orange; very large velvet-black mark on vertex, extending forwards on to frontal tubercle, which is rather small and feebly bifid. Rostrum a little shorter than head, orange, black at tip above and at sides, nasus well developed. Antennae and palpi black, structure as in *M. ferruginosa* and *M. aperta*. *Thorax* orange, with sharply defined velvet-black markings: three praescutal stripes, middle one very broad in front, undivided, well separated from lateral stripes; scutum with two large patches; a rather narrow stripe on pleurae, commencing a little below prothoracic stigma and continued across mesosternum; a pair of spots on apex of postnotum; and a spot on lower lateral sclerite of postnotum close to base of halteres. *Abdomen* deep orange, with a rather narrow black central stripe and less conspicuous lateral stripes. Hypopygium very much the same as in *M. dux*. *Legs* slender, black, coxae, front trochanters, and bases of front femora orange; femora slightly swollen apically. *Wings*

hyaline; stigma and cells C and Sc rather light brown. Cross-vein *r* present, rather short; Rs almost straight, less than twice as long as R_{2+3}; tip of Ax somewhat bent downwards. Halteres blackish, base of stem orange. *Length* of body, 10 mm.; wing, 16 mm.; hind leg, femur 9 mm., tibia 9 mm., tarsus 15 mm.

Mount Arthur Tableland, 3,000 ft., 11th January, 1891 (*G. V. Hudson*, No. 84B); type male in British Museum.

Macromastix brevitarsis n. sp.

Head orange; a rather small and narrow black vertical spot, scarcely reaching the small and slightly bifid frontal tubercle. Rostrum scarcely as long as head, black above and at sides, orange beneath; nasus short but distinct. Antennae and palpi black, base of first scapal joint orange. Flagellum eleven-jointed, the last six joints all very slender; first four joints all of equal length, short, the first one or two swollen, shortly oval. *Thorax* orange with velvet-black markings: three praescutal stripes, the middle one very broad, slightly enlarged in middle, where it is almost or quite in contact with lateral stripes; scutum with two rather broad stripes, constricted into two unequal parts; a well-defined stripe extending from front of middle praescutal stripe continuously to mesosternum, and sending a branch from prothoracic stigma almost to wing-base; postnotum with a double apical spot, the whole of lower lateral sclerite of postnotum black. *Abdomen* orange; a broad velvet-black median dorsal stripe, constricted in middle of second segment, and slightly enlarged on hind-margin of each tergite; narrower lateral black stripes, broadest near apex of second segment. Hypopygium hardly differing from that of *M. dux*. *Legs* coloured as in *M. auroatra*, but very much shorter and stouter. *Wings* with slight brownish tinge; veins dark brown; stigma and cells C and Sc blackish-brown. Venation as in *M. auroatra*. Halteres black, base of stem orange. *Length* of body, 11 mm.; wing, 16 × 4·2 mm.; hind leg—femur 7 mm., tibia 6·2 mm., tarsus 6·3 mm.

SOUTH ISLAND: The Hump, Southland (*A. Philpott*); type male in British Museum, presented by Mr. G. V. Hudson. Two additional males from the same locality sent me through Dr. C. P. Alexander; one of these is somewhat larger than the type, and differs slightly in venation, M_3 arising exactly at base of discal cell.

Macromastix dux (Kirby).

Tipula dux Kirby, *Trans. Ent. Soc. Lond.*, p. 270, 1884.

The following points are not mentioned in Kirby's description: Nasus well developed. Frontal tubercle distinctly bifid. Rostrum a little shorter than head, its sides black, under-surface orange. A large blackish mark adjoining eyes, at base of rostrum on each side. Pronotum orange above, blackish at sides. Middle sclerite of postnotum with broad blackish median stripe, lower lateral sclerite dark brown, upper one orange. A blackish stripe on pleurae running from wing-base to prothoracic stigma and thence at right angles downwards to mesosternum, its edge rather ill-defined. Hypopygium—ninth tergite somewhat emarginate; claspers rather short, a small hairy dorso-basal lobe, a shortly spiny apical lobe, a hairy ventral lobe, and a largely-bare dorsal portion, the inwardly-directed tip of which is somewhat bifid and bears short spines; parameres short and rounded. Front coxae orange; middle and hind coxae orange, with dark-brown markings. Front trochanters yellow at base, middle and hind ones all black. Front femora yellowish towards base. Costal and subcostal cells and stigma blackish-brown, not yellowish-brown as

stated by Kirby. Cross-vein *r* present and very distinct, meeting R_2 close to base. Halteres black, except at extreme base.

Locality unknown, but probably Auckland (*Dr. A. Sinclair*).

Macromastix aperta n. sp. (Fig. 102.)

♂. Differs from *M. dux* as follows: Dark stripe on vertex small and faint. No dark areas adjoining eyes at base of rostrum. Pronotum mostly blackish, only posterior margin narrowly reddish-orange. Praescutal stripes, especially middle one, much less distinct. Scutum almost entirely reddish-orange. Lower lateral sclerite of postnotum orange like upper one. No black stripe from prothoracic stigma to mesosternum. Central black stripe of abdomen much broader, leaving only narrow orange areas on each segment between central and lateral stripes. Wings with a slight brownish tinge. Cross-vein *r* absent. Ax straighter, tip not at all bent downwards. *Length* of body, 13 mm.; wing, 21·5 mm.; hind femur, 9 mm.; hind tibia, 9·5 mm.; hind tarsus, 12 mm.

Silverstream, Wellington, February, 1899 (*G. V. Hudson*, No. 166c); type male in British Museum; a second male in Cambridge Museum.

Another specimen (damaged, tip of abdomen missing) in British Museum is almost certainly the same species, but differs as follows: Nasus indistinguishable, represented by a tuft of long black hairs only. Pronotum orange. Thoracic markings further reduced, postnotum without dark area in middle. Presented by Captain F. W. Hutton in 1902, and determined by him as *Tipula dux*. I think the absence of a radial cross-vein in *M. aperta* and the differences in thoracic and abdominal markings will suffice to distinguish the two forms specifically. There are some very slight differences in the hypopygium, of uncertain value.

Macromastix ferruginosa n. sp.

Head reddish-orange, an ill-defined but large dark spot in middle. Front nearly half as broad as head, somewhat swollen, a slightly bifid tubercle above antennae. Rostrum reddish-orange, about as long as head; nasus black, rather long in the male, much shorter, a mere rounded projection, in the female. Palpi and antennae black. Flagellum eleven-jointed, joints nearly cylindrical, gradually and very slightly increasing in length to the fourth, then decreasing again; last four more slender and with more numerous hairs than first seven. *Thorax* ferruginous; a narrow darker central praescutal stripe, most distinct in female; apical margin of scutellum obscurely darker; a light-orange patch on pleurae extending from base of wing to prothoracic stigma. *Abdomen* with broad median and narrower lateral black stripes, the hind-margins of segments also narrowly black, those of segments 2–4 in the male more broadly so: between the black areas are orange side-spots on first seven segments. Hypopygium mostly orange, its structure practically as in *M. dux*. *Legs* black; coxae partly ferruginous; bases of front trochanters and front femora yellowish. In female the legs are somewhat shorter and more slender than in male. *Wings* as in *M. dux*, but with a slightly more pronounced brownish tinge to membrane. *Length* of body, 11·5 mm.: wing, ♂ 16·5 mm., ♀ 15 mm.: hind leg, ♂, femur 9 mm., tibia 10 mm., tarsus 15 mm.; ♀, femur 7·5 mm., tibia 8 mm., tarsus 10 mm.

North Island: Wainuiomata, Wellington, 11th February, 1921, glades in forest (*G. V. Hudson*, No. 166m); type male and one female in British Museum.

Though closely allied to *M. dux* and *M. aperta*, this is certainly a distinct species.

DIVISION II.

Rs shorter than R_{2+3}. Body at least partly green. Female abdomen pointed. Male antennae never elongate.

Macromastix virescens n. sp. (Fig. 172.)

♂. *Head* light greenish-ochreous; darker ochreous at sides and on rostrum, which is as long as head; nasus absent. Front about one-quarter as broad as head, tubercle rather small, bluntly pointed, forwardly directed. Palpi black, except towards base.. Scape of antennae pale ochreous, first joint slender. Flagellum blackish, ochreous towards base; first six joints distinct, elongate oval, slightly enlarged on under-side, third slightly longer than first or second, fourth and fifth shorter; last five very slender, cylindrical, indistinctly separated, slightly more hairy than preceding joints; terminal joint minute. *Thorax*—pronotum pale-greenish. Praescutum mainly rather deep ochreous, margins pale-greenish; traces posteriorly of three darker stripes, middle one blackish, divided by a pale line; lateral pair only outlined. Scutum with two ill-defined blackish patches in front. Scutellum, postnotum, and pleurae pale greenish-ochreous. *Abdomen* discoloured; probably uniformly light green in life. Ninth tergite broad, truncate, with four slight rounded terminal prominences. Tips of side-pieces scarcely produced. Claspers short and broad (see figure). *Legs* uniformly ochreous (perhaps green in life), long and slender. *Wings* with membrane very slightly milky, veins green, costa darker towards wing-tip. Costal cell scarcely tinted. Stigma pale-greenish. Cross-vein *r* at base of R_2, which is curved upwards and joins costa almost immediately beyond tip of R_1. Rs shorter than R_{2+3}. M_1 and M_2 slightly convergent; cell M_1 shortly stalked (stalk about one-eighth as long as cell). Cu_1 in punctiform contact with discal cell. Cell Ax rather broad, especially in the middle. Halteres very long; knob green, stem darker. *Length* of body, 15 mm.; wing, 22 mm.; halter, 4 mm.; hind leg, about 53 mm.

SOUTH ISLAND: Tisbury, 8th September, 1911 (*A. Philpott*); type male in Cawthron Institute collection.

Macromastix viridis (Walker). (Fig. 173.)

Tipula viridis Walker, *Ins. Laund. Dipt.*, p. 445, 1856.

♂. *Head* ochreous. Front about one-fifth as broad as head; tubercle rather small, slightly bifid at tip. Rostrum about as long as head, ochreous above, darker beneath; nasus distinct, but rather short and broad, blunt-ended. Antennae as in *M. virescens*, but third flagellar joint is slightly shorter than second. *Thorax* much as in *M. virescens*, but dark markings of mesonotum more extensive and conspicuous, lateral praescutal stripes solidly blackish, pleurae dusted with grey. *Abdomen* brownish-ochreous, dark brown towards apex, slightly shining, without distinct grey dusting. Hypopygium—ninth tergite with two large rounded lobes and a pair of triangular terminal projections, pubescent at tips; side-pieces with tips produced into sharp blackened points; claspers with very numerous short black spines (see figure). *Legs* very long and slender, rather dark brown, tarsi and tips of femora and tibiae almost black. *Wings* much as in *M. virescens*, but with a faint brownish rather than a milky tint; costal cell rather more distinctly tinged with brown; cell Ax broadest near base. Halteres shorter than in *M. virescens*, stem blackish. *Length* of body, 20 mm.; wing, 24 mm.; halter, 3 mm.; hind leg, 75 mm.

NORTH ISLAND: Karori, Wellington, December, 1920 (*G. V. Hudson*, No. 106); one male in British Museum. The above description has been

drawn up from this specimen; the figure of hypopygium is taken from Walker's type, which is damaged but obviously identical. These are the only two specimens I have seen, all others so determined proving to belong to related but distinct species.

Macromastix albistigma n. sp. (Figs. 114, 174.)

Differs from *M. viridis* as follows: Middle praescutal stripe obsolete, lateral pair conspicuously darker. Abdomen duller, more ochreous, tip not darkened, with rather broad lateral bands of grey dusting on all tergites except first. Hypopygium smaller, the claspers with a slightly different structure. Legs lighter in colour. Wings distinctly brown-tinged, lower pre-arcular cell, costal and subcostal cells, base of cell R_2 and veins dark brown; stigma conspicuously whitish-ochreous. Cell M_1 sessile in some specimens; cell Ax broadest in the middle. Length of body, ♂ 16–17 mm., ♀ 17–20 mm.; wing, 18–23 mm.; halter, about 3 mm.; hind leg, ♀ 45–50 mm.

South Island: Spreydon, Canterbury, January, 1920, one female, in Canterbury Museum; West Plains, 4th February, 1903, one female (wing figured). Also five males, all damaged, in Osten-Sacken collection in Berlin-Dahlen Museum, without locality label; none of these is sufficiently well preserved to select as a holotype.

The ovipositor of female, though rather long and sharply pointed, has hairy valves which are no more strongly chitinized than the general integument of the abdomen.

Macromastix holochlora (Nowicki). (Fig. 175.)

Tipula holochlora Nowicki, *Beitr. z. K. der Dipt. Neuseelands*, p. 9, 1875.

Though certainly nearly allied to *M. viridis*, this has wrongly been regarded as synonymous with that species. The hypopygia are very distinct (compare figures), and *M. holochlora* may further be distinguished from other members of the group by the entirely green thorax, the mesonotum having only a slight ochreous tinge (probably none in life), and no trace of dark praescutal stripes. Cell Ax broadest near middle.

There are apparently two varieties, differing as follows: (*a*.) Abdomen entirely green; tips of femora and tibiae scarcely darkened; wings practically hyaline; stigma entirely pale-greenish; cell Ax moderately broad. This is the typical *M. holochlora*. (*b*.) Abdomen brownish-green except towards base; tips of femora and tibiae more distinctly darkened; wings greyish-tinged; stigma dark grey at base; cell Ax narrower. Length of body, 10–20 mm.; wing, 14–22 mm.

North Island: Neighbourhood of Auckland, 1854 (*Colonel Bolton*), two females of typical form in British Museum; Karori, Wellington, December, 1920 (*G. V. Hudson*, No. 323), one male of var. *b*, one female of typical form, in British Museum; Te Wairoa, 15th November, 1919 (*D. Miller*), one male of typical form. South Island: West Plains, 6th February, 1906, one male of var. *b*.

Division III.

Rs at most slightly longer than R_{2+3}. Female abdomen blunt-ended. Male antennae frequently elongate.

Macromastix maori Alex. (Fig. 104.)

Macromastix maori Alexander, *Insecutor Inscitiae*, vol. 8, p. 130, 1920.

Apart from wing-markings, which will at once distinguish it from all others found in New Zealand, this species is remarkable for the possession of a vein-stump in middle of M projecting into cell M, much as in the two species of *Holorusia*.

SOUTH ISLAND: Tisbury, July–August, 1912 (*A. Philpott*); two males in Alexander's collection. Also one male (type) in Berlin-Dahlem Museum, from Osten-Sacken's collection (the wing of this specimen figured).

Macromastix binotata Hutton. (Fig. 105.)

Macromastix binotata Hutton, *Trans. N.Z. Inst.*, vol. 32, p. 32, 1900.

The distinctive wing-markings of this species bear some slight resemblance to those of *M. maori*, but there is no vein-stump in cell M. Another point of resemblance to *M. maori* is the narrowness of front, which is scarcely a quarter as broad as head. The first antennal joint is rather short and not particularly swollen; flagellum eleven-jointed, all joints rather elongate and about equal in length, except last, which is globular.

NORTH ISLAND: Wellington district (*G. V. Hudson*, No. 87). A rare species, found in midwinter. Female probably semiapterous.

Macromastix lunata Hutton. (Fig. 106.)

Macromastix lunata Hutton, *Trans. N.Z. Inst.*, vol. 32, p. 32, 1900.

In this species male antennae nearly three times length of whole body; frontal tubercle and basal antennal joint of male much enlarged, the latter ochreous in colour; head has large dark spot between eyes, covering most of frontal tubercle; front is very broad, about half as broad as head; rostrum about as long as head, straight; nasus more or less bifurcate at tip, moderately long. *Thorax* rather conspicuously hairy on whole surface. Praescutum with three dark-brown or black stripes on grey or ochreous-grey ground, middle stripe divided by grey line of varying width. Pleurae dark grey; pale ochreous between wing-base and pronotum, and below this with a single velvet-blackish spot towards front. *Abdomen* with orange ground-colour on tergites, an irregular black dorsal stripe, broadest on basal half of second segment; sides of the basal half of second segment, of third, fourth, and fifth segments, and whole of sixth and seventh segments, as well as almost whole of venter, are ash-grey. *Wings* as in figure; small pre-arcular cells and cells M_1 and M_2 are dark; the pale markings are whitish, except in cell R_3 which is yellow towards base; cell Ax broad; stem of cell M_1 from a quarter to a third as long as the cell; R_2 somewhat sinuous, nearly vertical. *Length* of body, 9–10 mm.; wing, 14–16 mm.; antennae, ♂ 27–30 mm.; hind leg, ♂ 31 mm.

NORTH ISLAND: Wellington district (*G. V. Hudson*, No. 108). British Museum collection contains two damaged cotypes presented by Captain Hutton, a perfect male presented by Dr. H. Scott, and another presented by Mr. Hudson. Other specimens are in Cambridge Museum.

Macromastix variegata n. sp. (Fig. 107.)

Differs from *M. lunata* as follows: Scape of antennae darker; rostrum distinctly longer and slightly curved, nasus very short; praescutal stripes

lighter; black mark on second abdominal segment smaller; wings broader, pale markings more extensive; pre-arcular cells and cell M_1 almost all whitish; pale portion of cell R_3 with only a faint yellowish tinge; cell Ax rather more extensively dark at base. Length of body, 12–13 mm.; wing, ♂ 19 mm., ♀ 17 mm.; antennae, ♂ 33 mm., ♀ 2·5 mm.

NORTH ISLAND: Forest, Kaeo, North Auckland, January, 1913 (*G. V. Hudson*, No. 294); type male and one female in British Museum. The female differs from male in having a smaller pale area in tip of cell M.

Macromastix decorata n. sp. (Fig. 108.)

Head, including rostrum and antennae, rather light brown, dull. Frontal tubercle well developed, rather larger in male; front with long but not very dense pale hair. Front nearly half as broad as head, nasus bifurcate at tip. Antennae as long as head and thorax together in male, shorter than thorax in female; thirteen-jointed. Basal joint much swollen in male. Flagellum evenly tapering in male; in female the first five flagellar joints thicker than others, almost cylindrical but slightly enlarged apically; last two joints short, somewhat thicker than preceding four, so that to the naked eye antenna appears slightly clubbed. *Thorax* rather light greyish-brown, dull, with short and rather dense pale hair. Praescutum with four dull dark-brown stripes; scutum mostly dark brown. Pleura greyer than mesonotum, anteriorly with two chocolate-brown spots one above the other, bordered with lighter brown. *Abdomen* ochreous-brown, nearly bare; greater part of venter, basal half of tergite 2, and whole of tergites 5 and 7 whitish-grey; tergite 2 with a pair of transverse shining patches in middle; dark median line on segments 1–5, less distinct and interrupted in female; sides of tergites 2 (apical half), 3, 4, and 6 dark chocolate-brown. *Wings* rather dark brown, lighter in anal and posterior cells, more yellowish-brown in costal cell; a large lunate white mark in apical half of basal cells, spreading over greater part of discal cell; cell R_2 mostly white; basal half of cell R_3 yellow; R_5 a little longer than R_{2+3}, R_2 about half as long, arising at an angle of 60°; stem of cell M_1 about one-eighth as long as cell; Cu_1 fused with M_3 for a short distance; cell Ax large, broadest near base. *Legs* rather dark brown, tips of joints darker. Last tarsal joint in male somewhat swollen, especially at base beneath. Empodia nearly as long as claws. *Length* of body, 12 mm.; wing, 19 mm.; antennae, ♂ 4·5 mm., ♀ 2·5 mm.

NORTH ISLAND: Wainuiomata, Wellington, Christmas, 1906, and 15th December, 1920 (*G. V. Hudson*, No. 210); type male, one other male, and one female in British Museum.

Close to *M. lunata* Hutton, but differs in the markings of wings and abdomen, and in length of male antennae.

Macromastix huttoni n. sp. (Fig. 109.)

Head dull dark ochreous, scarcely any darker in middle, with some ochreous-grey dusting round eyes. Front about one-quarter as broad as head, tubercle moderate. Rostrum slightly longer than head, rather darker than vertex; nasus with long hairs at tip, which is not bifid. Palpi blackish. Antennae rather dark brown, alike in both sexes; shorter than thorax. first scapal joint slender. First flagellar joint slightly shorter than second, third, or fourth; fifth and sixth shorter; last five thinner and indistinctly separated. *Thorax* resembling that of *M. lunata*, but much less hairy, and area above blackish pleural spot is not conspicuously pale. *Abdomen* much as in *M. lunata*, but without conspicuous grey dusting on any part;

the blackish dorsal line is narrower, especially on second segment. *Legs*, especially tarsi, distinctly longer and more slender than in *M. lunata*; femora and tibiae brown with black tips; tarsi darker. *Wings* resembling those of *M. lunata*, but there is a small white streak before humeral cross-vein, and a whitish mark in cell M_1; the stem of this cell is shorter (one-fifth to one-eighth as long as the cell). *Length* of body, 9–10 mm.; wing, 14–16 mm.; hind leg, ♂ 38–42 mm.

NORTH ISLAND: Wellington, in forest, February, 1914, and 11th March, 1921 (*G. V. Hudson*, No. 311); type male, one other male, and one female in British Museum. Another male, without exact locality label, is in Berlin-Dahlem Museum, bearing the label "*huttoni* O.-S.," in Osten-Sacken's handwriting.

Macromastix vittata n. sp. (Fig. 110.)

♂. *Head*, including rostrum, reddish-ochreous, somewhat dusted with grey; a large dark spot in middle of vertex, extending on to the rather small frontal tubercle. Front about one-third as broad as head. Rostrum very slightly longer than head; nasus not bifid. Antennae about as long as the praescutum; scape reddish-ochreous, flagellum dark brown; last five joints short, together scarcely longer than preceding two together. *Thorax* with short pale hair over whole surface. Pronotum reddish-ochreous. Mesonotum dark grey. Praescutum with three black stripes, middle one just divided by a dark line; lateral pair extending across scutum. Pleurae leaden-grey, space between wing-base and pronotum reddish-ochreous, no dark marking below this. *Abdomen* reddish-ochreous; a black median dorsal stripe, broadening out on segment 4 and occupying whole of segments 5–8; venter similarly coloured. *Legs:* Coxae leaden-grey. Femora ochreous-brown, blackish towards tip; tarsi not quite as long as tibiae. *Wings* with markings of the *M. lunata* type, but white markings tending to form a streak running from base of cell Ax to base of cell R_2. Pre-arcular cells mostly whitish. Pale portion of cell R_3 with scarcely any yellowish tinge. Cell M_1 dark, its stem about one-quarter as long as cell. Cell Ax very narrow, nearly all pale. *Length* of body, 11 mm.; wing, 17 mm.; hind leg, 46 mm.

NORTH ISLAND: Wellington (*G. V. Hudson*, No. 108B), type male in British Museum; Mount Ngongotaha, 2,550 ft., 15th February, 1910 (*Dr. G. B. Longstaff*), one male in Oxford Museum.

Macromastix alexanderi n. sp. (Fig. 111.)

♂. *Head* dark reddish-ochreous, paler on posterior eye-margins, not any darker in middle. Front about one-quarter as broad as head, with a rather small tubercle. Rostrum scarcely as long as head; nasus very short, scarcely distinguishable. Palpi and antennae blackish-brown. First scapal joint slender. Flagellum ten-jointed, first five joints gradually diminishing in length, somewhat swollen beyond middle; last five joints distinct, short, very little more slender than first five (except last joint, which is slender). *Thorax* nearly bare, dark brownish-grey, praescutum with three rather ill-defined dull black stripes, middle one not divided. Pleurae without markings. *Abdomen* dark reddish-brown; black dorsal line on segments 1–4, segments 5–8 wholly blackish grey. *Legs* blackish-brown, femora lighter towards base. *Wings* somewhat resembling those of *M. vittata*, but pre-arcular cells are dark; a large dark patch along Cu in apical half of cell M; stem of cell M_1 about half as long as the cell,

and cell Ax is moderately broad. *Length* of body, 9 mm.; wing, 16 mm.; hind leg, 38 mm.

SOUTH ISLAND: Otira, November, 1918; type male (unique) in Canterbury Museum.

I have much pleasure in dedicating this species to Dr. C. P. Alexander, through whose kindness I received the Canterbury Museum collection for study.

Macromastix fumibasis n. sp. (Fig. 112.)

Head dark brown in middle, shading to ochreous-grey round the eyes. Front about one-third as broad as head, tubercle moderate. Rostrum about as long as head; nasus well developed, but broad and blunt. Antennae with the scape ochreous; flagellum dark brown with ten distinct almost cylindrical joints, gradually decreasing in length and thickness, eleventh joint minute. *Thorax* with short but rather dense pale pubescence; mesonotum dull dark brown, the praescutum with four obscurely darker stripes; pleurae lighter. *Abdomen* rather dark brown, slightly shining and ochreous-tinged towards base; dull and somewhat greyish towards tip. *Legs* moderately slender, ochreous-brown, tips of femora and tibiae darker. *Wings* brownish over greater part of surface, much darker towards base and in costal cell; a whitish area across M before middle, and a larger one at apex of cell R, extending into adjoining cells, except R_{4+5}. R_2 oblique and nearly straight; base of R_{4+5} blackened and bent downwards; cell M_1 nearly three times as long as its stem. *Length* of body, 11–12 mm.; wing, 17 mm.; hind leg, 28 mm.

SOUTH ISLAND: Tisbury, 6th February, 1918, and 6th March, 1912 (*A. Philpott*); type and another female in Cawthron Institute collection.

Macromastix fucata Hutton.

Macromastix fucata Hutton, *Trans. N.Z. Inst.*, vol. 32, p. 31, 1900.

The thoracic and abdominal markings are distinctive, especially the orange scutellum and base of pronotum, which contrast strongly with the rest of thorax; black markings of abdomen are not dusted over with grey, as they are in *M. montana* and to a less extent in *M. vulpina*. In female which I have examined there are some slight divergences from Hutton's description: the sides and under-part of rostrum are black; head mostly blackish-grey, except for a rather narrow ochreous median line; pronotum dull brownish-ochreous; first antennal joint mostly dark, second and third ochreous; first segment of abdomen mostly reddish, dusted over with grey; sides of third segment and of apical half of fourth also have reddish ground-colour. It may also be noted that Hutton has evidently regarded the two parts of the second segment as distinct segments. Antennal flagellum eleven-jointed, first eight joints gradually decreasing in size, convex and pubescent below, last two joints indistinctly separated, each slightly larger than ninth. On wings, Rs is nearly as long as R_{2+3} and R_2 together; cell M_1 is almost parallel-sided, about twice as long as its stem; cell Ax is narrow, slightly broader in middle.

Male differs from female as follows: Rostrum with dark area at tip on upper surface. Antennae all black, the last four flagellar joints slender. Head (except for ocherous central line), praescutum, and scutum almost all dull black (perhaps partly on account of discoloration of grey areas). Thoracic hair longer and denser. Sixth and seventh abdominal tergites much more extensively black. Tarsi longer. Cell Ax slightly narrower.

NORTH ISLAND: Wellington district (*G. V. Hudson*, No. 151); one female in British Museum from dense forest, Wainuiomata, 15th December, 1920. SOUTH ISLAND: Otira, December, 1908 (*G. V. Hudson*); The Hump, 24th December, 1915 (*A. Philpott*), one male in Cawthron Institute collection. It is just possible that the two specimens are not conspecific. Further material of each sex from both localities will decide the point.

Macromastix cinerea n. sp.

♀. *Head* dark grey, with some pale hair; front about one-third as broad as head, without tubercle; rostrum scarcely as long as head, moderately hairy, with distinct nasus. First scapal joint long, rugose; second very small. Flagellum eleven-jointed; first joint enlarged, especially on under-side; next five joints also slightly enlarged on under-side, gradually decreasing in size; last five joints somewhat more slender, last two indistinctly separated and slightly thicker than seventh to ninth. *Thorax* ash-grey, praescutum with traces of four darker stripes, and with rather long and dense dark hair on interspaces. An ochreous patch on pleurae between wing-base and prothoracic stigma. *Abdomen* ash-grey above, buff-coloured below. *Legs* rather long and slender, blackish-brown, coxae and bases of femora lighter. *Wings* hyaline, stigma scarcely darker, veins dark brown. Rs very short, shorter than R_{2+3} and hardly longer than R_2; stem of cell M_1 about half as long as cell; cell Ax moderately broad. Halteres brownish. *Length* of body, 11 mm.; wing, 14·5 mm.; hind tibia, 7·7 mm.; hind tarsus, 20 mm.

SOUTH ISLAND: Arthur's Pass, 3,000 ft., December, 1914 (*G. V. Hudson*, No. 322); type and one other female in British Museum.

Macromastix vulpina (Hutton). (Fig. 116.)

Megistocera vulpina Hutton, *Cat. N.Z. Dipt.*, p. 16, 1881.
Marcomastix vulpina Osten-Sacken, *Berl. ent. Zeitschr.*, vol. 30, p. 185, 1886; Hutton, *Trans. N.Z. Inst.*, vol. 32, p. 30, 1900.

An easily recognized species, on account of short, stout body, elongate male antennae, and practically unmarked wings. The long, dense, pale hair of thorax shows the close relationship to *M. montana*, but *M. vulpina* may be readily distinguished from this species by the four distinct praescutal stripes, the much paler abdomen, the relatively shorter legs (especially tarsi), and the rather conspicuous milky tinge to wings. As stated by Osten-Sacken, the female antennae are thirteen-jointed, last five joints more slender and indistinctly separated. Stem of cell M_1 is from one-half to two-thirds as long as cell. *Length* of body, ♂ 10 mm., ♀ 11 mm.; wing, 14 mm.; hind tibia, 8 mm.; hind tarsus, ♂ 11·5 mm., ♀ 8·5 mm.

SOUTH ISLAND: Dunedin (*Hutton*); Lake Wakatipu (*G. V. Hudson*, No. 191); series in British and Cambridge Museums. Mount Grey, Canterbury, January, 1918; one male in Canterbury Museum.

Macromastix montana Hutton.

Macromastix montana Hutton, *Trans. N.Z. Inst.*, vol. 32, p. 31, 1900.

Head ash-grey, densely covered with long pale hair. Rostrum as long as head, with short but distinct nasus. Frontal tubercle rather small. Antennae alike in both sexes. First scapal joint rather long, cylindrical, greyish, second small. Flagellum with nine joints, first four about equal

in length, somewhat convex below and somewhat narrowed at base, especially on upper side; remaining joints gradually decreasing in length and size, except last, which is somewhat stouter than penultimate. *Thorax* ash-grey, densely and uniformly covered with long pale hair. Praescutum with three black stripes, middle one very broad, undivided, lateral ones continued across scutum. Scutellum, postnotum, and pleurae unmarked. *Abdomen* with short and rather sparse pale pubescence; in male the ground-colour is ash-grey, second tergite being reddish on basal two-thirds, with an interrupted blackish middle line, venter also largely reddish-tinged; in female, as in male, the basal portion of second tergite is reddish, without any grey dusting, whole of the rest of abdomen being heavily dusted, but the ground-colour reddish, with a rather broad blackish median dorsal stripe narrowed but not interrupted on reddish portion of second tergite. *Legs* black, basal halves of femora indeterminately orange; coxae and trochanters dusted with grey. *Wings* slightly smoky, more distinctly so in cells C and Sc and towards bases of cell R and M; stigma brown. Rs of same length as R_{2+3}; *r* meeting R_2 near base; stem of cell M_1 at most one-fifth as long as cell; cell Ax very broad. Halteres light-brownish. *Length* of body, 15–16 mm.; wing, 22–23 mm.; hind tibia, ♂ 17 mm., ♀ 16 mm.; hind tarsus, ♂ 36 mm., ♀ about 24 mm.

North Island: Mount Ruapehu, 4,000 ft. South Island: Mountains round Lake Wakatipu (*G. V. Hudson*, No. 137).

The above description is drawn up from a male and female in British Museum from Mount Earnslaw, 3,500 ft., Lake Wakatipu, sent as *M. montana* by Mr. Hudson. There is another similar female in Cambridge Museum, also named and presented by Mr. Hudson. These specimens differ in several respects from Hutton's diagnosis, and may perhaps represent another species, but I think the main differences can be accounted for by supposing that Hutton described from discoloured specimens, in which the heavy grey dusting was obliterated, and the ground-colour consequently showed darker than usual; and by further assuming that he accidentally reversed his statements regarding the male and female abdomens.

Macromastix submontana n. sp.

♀. Differs from *M. montana* as follows: Black stripe of abdomen narrower, base of second segment less conspicuously red. Wings hyaline except for dark stigma and slight smokiness towards base of costal cell. Cross-vein *r* meeting R_2 near the middle. Cell M_1 scarcely longer than its stalk. *Length* of body, 13 mm.; wing, 18 mm.; hind tibia, 11 mm.; hind tarsus, 19 mm.

South Island: Mount Cleughearn, 13th January, 1916 (*A. Philpott*); type female in Cawthron Institute collection.

Macromastix minor n. sp. (Fig. 118.)

♂. *Head* blackish, lighter round hind-margins of eyes; frontal tubercle rather small, rounded. Front, vertex, and under-surface of rostrum clothed with long black hair. Antennae short, black, thirteen-jointed, first six flagellar joints distinct, somewhat oval, nearly straight above, enlarged slightly on ventral side, gradually decreasing in size, remaining five joints cylindrical, indistinctly separated, about equal in length, together as long as and much more slender than three preceding joints. *Thorax* blackish-grey, clothed with rather long and dense black hair; praescutum with

four black stripes. *Abodmen* orange-red, black at sides and with broad median dorsal black stripe, last two or three segments almost entirely black ; hair dark, shorter than that of thorax. *Legs* black, femora brown at base ; last tarsal joint not swollen. *Wings* almost colourless except for the black veins and the conspicuous dark-brown stigma ; in certain lights whitish areas are visible at base of cell R_2, in apices of the cells R and M, and before middle of cell M. Marginal cross-vein distinct. Rs equal in length to R_{2+3}, R_2 half as long. Stem of cell M_1 about a quarter as long as cell. A short *m*–Cu cross-vein present. Fold below Cu not darkened. Vein Ax ending scarcely beyond anal angle of wing ; cell Ax very narrow and of even width throughout, not carried back beyond base of vein Ax. *Halteres* black, base of stem orange. *Length* of body, 7·5 mm. ; wing, 10·5 mm. ; hind tibia, 7·2 mm. ; hind tarsus, 14·2 mm.

SOUTH ISLAND : Tableland of Mount Arthur, 4,000 ft., February, 1910, on tussock-grass (*G. V. Hudson*, No. 253).

Macromastix rufiventris n. sp. (Fig. 117.)

♂. Very similar to *M. minor*, differing as follows : Hair on thorax and abdomen light-yellowish instead of black. Black abdominal stripe narrower and narrowly interrupted on margins of the segments ; tergites 5–8 black in middle, grey at sides. *Wings* tinged with fuscous on greater part of surface, leaving three clear spaces, one in pre-arcular cell, one at apex of upper basal cell and base of discal cell, and one in middle of lower basal cell. Last five antennal joints shorter, rounded. *Length* of body, 7·5 mm. ; wing, 11·5 mm. ; hind tibia, 9 mm. ; hind tarsus, 17 mm.

♀. Resembles male in most respects, but abdomen is more ochreous than orange, central black stripe being narrower and obsolete on last few segments ; cell Ax of wings is quite twice as broad, and broadest in middle. *Length* of body, 9–10 mm. ; wing, 14 mm. ; hind tibia, 8 mm. ; hind tarsus, 11·5 mm.

NORTH ISLAND : Wellington district, "formerly (1891) extremely abundant on hilltops, now (1921) very rare ; February" (*G. V. Hudson*, No. 124) ; type male and one female in British Museum.

Macromastix cubitalis n. sp. (Fig. 113.)

♀. *Head* dull-brownish. Front about one-third as broad as head, tubercle scarcely developed. Rostrum about as long as head ; nasus short. Scape of antennae ochreous ; flagellum dark brown, ten-jointed, the joints nearly cylindrical and all rather slender, first joint longer than scape, second not quite so long, following joints gradually shorter, except last which is longer again. *Thorax* with a certain amount of longish but not very conspicuous hair ; colour dull-brownish, praescutum with four narrow and ill-defined darker stripes. *Abdomen* dull-brownish, lighter towards base, darker on margins, fifth segment rather distinctly dusted with grey. *Legs* slender, brownish ; tarsi and tips of femora and tibiae darker. *Wings* greyish-tinged, veins brown ; stigma rather dark brown ; a fairly obvious brown seam over Cu_{1a}, which meets M at base of discal cell ; discal cell open on one wing ; cell M_1 with very short stalk. Halteres dark brown. *Length* of body, 8·5 mm. ; wing, 10·5 mm. ; hind tibia, 5·7 mm. ; hind tarsus, 9 mm.

NORTH ISLAND : Karori, Wellington, April–May (*G. V. Hudson*, No. 280c) ; type female in British Museum.

Macromastix pallida Hutton.

Macromastix pallida Hutton, *Trans. N.Z. Inst.*, vol. 32, p. 31, 1900.

Hutton's brief description omits mention of what is perhaps the most characteristic feature of the species, the length and slenderness of abdomen when compared with other species of the genus. The first antennal joint is also unusually short, and the penis is much stouter than in any other species which I have examined, though in other respects the structure of the hypopygium is typical of *Macromastix*. There is some variation in the position of the radial cross-vein, which in some specimens is placed exactly at or even immediately before the base of R_{4+5}. The halteres are unusually long, and, like the antennae and legs, are light-brownish.

North Island: Wellington district (*G. V. Hudson*, No. 110); "a winter species, extremely rare; female unknown, probably semi-apterous" (*Hudson*); three males in British Museum. South Island: Invercargill, 18th April, 1919; West Plains, 8th February, 1901 (*Philpott*).

Macromastix obliqua n. sp. (Figs. 115, 176.)

♂. *Head* dark brown, a narrow greyish-ochreous border to eyes, an ill-defined black central line. Antennae missing. Rostrum about as long as head; nasus absent. *Thorax* dark ochreous-brown, with short and inconspicuous pale pubescence. Praescutum with three dark-brown stripes, middle one divided in front by a pale line; front margin between stripes blackish; a brown spot on pleurae a little below prothoracic stigma. Postnotum dark apically, its lower lateral sclerite dark brown, rather sharply contrasting with the pale upper one. *Abdomen* dark brown, tergites darker apically, and with some greyish dusting on sides, particularly noticeable on segments 3, 4, 6, and 7. Hypopygium of peculiar form: the ninth tergite very broad and short, almost completely divided into two large hairy lobes which probably take the place of the reduced claspers; side-pieces narrow, with bare rounded blackened tips; claspers with a bare rounded black basal lobe. *Legs* moderately stout, dark brown. *Wings* nearly hyaline, somewhat iridescent, the costal cell very slightly darker, stigma light brown. Veins dark brown, except for a short pale area on Cu just before fork, and tip of R_2. R_2 very oblique, twice as long as *r*. Base of R_{4+5} as long as *r-m*, the two forming a perfectly straight line. Cell M_1 sessile. Cu_{1a} very oblique, parallel with costa, the angle between it and Cu_2 only about 50°. Cell Ax moderately broad. Halteres blackish; base of stem and tip of knob ochreous. *Length* of body, 11 mm.; wing, 15·5 mm.; hind leg, 38 mm.

North Island: Papatotara, 26th January, 1911; type male in British Museum.

Macromastix incerta n. sp.

♀. *Head* blackish-brown in middle, broadly greyish-ochreous round eyes. Rostrum shorter than head; nasus absent. Front fully one-third as broad as head, with a scarcely perceptible tubercle. Antennae with scape greyish-ochreous; flagellum blackish. First scapal joint slender. Flagellum distinctly ten-jointed; first two joints somewhat swollen beneath; remaining joints rather elongate oval, gradually and slightly diminishing in length and thickness. *Thorax* and *abdomen* coloured as in *M. obliqua*, except that there is no dark patch on pleurae below prothoracic

stigma ; mesonotum somewhat shining, and praescutal stripes less distinct. *Legs* darker brown, rather shorter and more slender than in *M. obliqua*. *Wings* hyaline, costal cell without trace of darkening, stigma dark brown ; veins all dark brown, no trace of pale area on Cu. Rs very short, shorter and straighter than in *M. obliqua*. R_2 less oblique than in *M. obliqua*, scarcely longer than *r*. Basal section of R_{4+5} much shorter than *r-m*, which is somewhat curved. Cell M_1 with a short stalk (about one-sixth as long as cell). Cu_{1a} almost normal, not nearly so oblique as in *M. obliqua*. Knob of halteres entirely dark. *Length* of body, 10 mm. ; wing, 13 mm. ; hind leg, 27 mm.

NORTH ISLAND : Papatotara, 26th February, 1911 ; type female in British Museum.

It is quite possible that this may be the female of *M. obliqua*, especially as it was taken at the same place by the same collector on the same day, and has almost the same rather peculiar thoracic coloration ; the differences in the wings seem, however, to preclude this supposition.

Macromastix zeylandiae Alexander. (Figs. 121, 177.)

Macromastix zeylandiae Alexander, *Insecutor Inscitiae*, vol. 8, p. 131, 1920.

Tipula obscuripennis Hutton (*nec* Kirby), *Trans. N.Z. Inst.*, vol. 32, p. 28, 1900.

There are two slight inaccuracies in Alexander's description : the pleurae are almost uniformly grey, with little or no trace of stripes, and the pale pubescence of the mesonotum is uniformly distributed, not confined to the praescutal interspaces. The praescutal stripes, as is frequently the case in other species, are variable in colour, the middle pair being very faint, the lateral pair also somewhat faint, in most of the North Island specimens I have seen. Antennae alike in both sexes, flagellum ten-jointed, last five joints somewhat more slender and together about two-thirds as long as first five. Female resembles male in coloration, but has much shorter and somewhat stouter legs, and rudimentary wings.

A pair presented to the British Museum by Mr. G. V. Hudson show the following measurements : Length of body, ♂ 10·5 mm., ♀ 12·5 mm. (distended with eggs) ; wing, ♂ 16 mm., ♀ 4·5 mm. ; hind tibia, ♂ 7·5 mm., ♀ 5·8 mm. ; hind tarsus, ♂ 27 mm., ♀ 8·3 mm.

NORTH ISLAND : Papatotara, 26th February, 1911, one male ; Karori, Wellington, February–March (*G. V. Hudson*, No. 69). SOUTH ISLAND : Christchurch (*Hutton*), a pair in British Museum, presented by Captain Hutton and named by him *Tipula obscuripennis ;* Mount Grey, Canterbury, November, 1916, one male in Canterbury Museum ; Otago (*Osten-Sacken*), Alexander's type male in Berlin-Dahlem Museum.

Very similar in many respects to *M. obscuripennis*, but differs in the reduced wings of female, the stouter legs in both sexes, and in having a distinct clear spot on each side of stigma in wing of male.

Macromastix dichroithorax Alexander. (Figs. 119, 178.)

Macromastix dichroithorax Alexander, *Insecutor Inscitiae*, vol. 8, p. 133, 1920.

As stated by Alexander, this is similar in most respects to *M. zeylandiae*, differing most conspicuously in the very much narrower cell Ax. Apart from this, the pale marks on each side of the stigma are scarcely perceptible,

and the lateral praescutal stripes, though variable in intensity of coloration, are always darker than the middle stripes. The sexes are alike as regards antennae and wings. The flagellum is ten-jointed, the last five joints very short, rather indistinctly separated, and together not longer than the fourth and fifth joints together.

NORTH ISLAND: Karori, December, abundant (*G. V. Hudson*, No. 127); one female in British Museum. SOUTH ISLAND: Otago (*Osten-Sacken*); a number of specimens in Oxford Museum, collected by C. M. Wakefield, probably from Canterbury.

Macromastix sinclairi n. sp. (Figs. 120, 179.)

Head greyish-ochreous, greyer round eyes, somewhat darker in middle. Front about one-quarter as broad as head, tubercle rather prominent, slightly bifid. Rostrum scarcely as long as head, brownish-ochreous; nasus broad, blunt-ended. Antennae brownish-ochreous, somewhat darker apically; first scapal joint slender. Flagellum eleven-jointed; first eight joints gradually diminishing in size, rather elongate oval, somewhat more convex beneath; last three joints rather more slender and each a little longer than the eighth. *Thorax* dull brownish-ochreous, with short, uniformly distributed and rather dense pale pubescence. Praescutum with three darker-brown stripes, middle one broad and undivided. *Abdomen* dark-brownish, more ochreous at sides, towards base, and on venter. Hypopygium as in figure; note especially the form of ninth tergite, which can be seen even in the dry specimen. Ovipositor normal. *Legs* slender; no stouter and not much shorter in female than in male; brown, tips of femora and tibiae darker. *Wings* alike in both sexes, except that in the female cell Ax is slightly broader; brownish-tinged, costal cell somewhat darker, stigma rather dark brown; scarcely perceptible paler areas on each side of stigma. R_2 nearly straight, nearly vertical, pale; *r* placed near middle of R_2; Rs about equal to R_{2+3}; cell M_1 about half as long again as its stem; cell Ax rather narrow. Halteres brownish. *Length* of body, ♂ 9 mm., ♀ 8–10 mm.; wing, 12–14 mm.; hind tibia, ♂ 9 mm., large ♀ 7·5 mm.; hind tarsus, ♂ 23 mm., ♀ 13 mm.

NORTH ISLAND: Auckland? (*Dr. A. Sinclair*, 1845), one male and two females in Kirby's series of *Tipula obscuripennis;* Karori, Wellington, March–April (*G. V. Hudson*, No. 201), two males (including type) and two females in British Museum.

Macromastix obscuripennis (Kirby). (Fig. 180.)

Tipula obscuripennis Kirby, *Trans. Ent. Soc. Lond.*, p. 271, 1884.

♂. Differs from *M. sinclairi* as follows: Head more ochreous, scarcely greyer round eyes. Front somewhat broader, nearly one-third as broad as head, tubercle not in the least bifid. Flagellum ten-jointed, last six joints distinctly more slender than first four, and together as long as joints 2–4 together. Thorax greyer, praescutal stripes darker, middle one distinctly divided for its whole length by greyish line. Abdominal segments 5–6 rather conspicuously grey-dusted. Hypopygium as figured, resembling but distinct from that of *M. dichroithorax*. *Length* of body, 9 mm.; wing, 14 mm.; hind tibia, 9 mm.; hind tarsus, 20 mm.

NORTH ISLAND: Auckland? (*Dr. A. Sinclair*, 1845). Kirby's series consisted of two males and two females (he had overlooked the fact that he had both sexes before him); of these one male and two females are

now referred to *M. sinclairi*, described above. I have selected the fourth specimen as the type of *M. obscuripennis*, because it is the only one which agrees with Kirby's statement that the middle thoracic stripes are divided by a narrow pale line.

Genus HUDSONIA n. gen.

Allied to *Macromastix*, and agreeing with that genus in its venation and its non-verticillate antennae, but (1) the antennae are reduced in both sexes, both in length and in the number of joints, the reduction being greater in the female; (2) the male hypopygium is large and normal in position, not small and twisted to one side as in *Macromastix;* (3) the ovipositor has long horny anal valves as in *Tipula*, *Holorusia*, *Longurio*, &c.; (4) in both sexes the sensory pits on the praescutum (pseudosutural foveae of Alexander) are larger than in *Macromastix;* (5) the palpi are short, the fourth joint scarcely longer than the third.

This genus is erected for the single species *Tipula heterogama* Hudson, which cannot be satisfactorily placed in *Macromastix*, on account of the horny ovipositor; in *Holorusia*, on account of the venation of the male; or in *Longurio* or *Tipula*, on account of the absence of verticils on the antennae. I have much pleasure in dedicating the genus to Mr. G. V. Hudson, the discoverer and describer of the type species. I do not consider the name *Hudsonia* to be preoccupied by *Hudsonius* Gir., 1856 (Pisces).

The reduction of the female antennae is very interesting, and seems to foreshadow the somewhat similar condition in the Brachycera. I do not know of another case among the Nematocera in which reduction of the wings is accompanied by reduction of the antennae.

Hudsonia heterogama (Hudson). (Fig. 122.)

Tipula heterogama Hudson, *Trans. N.Z. Inst.*, vol. 45, p. 68, 1913.

♂. *Head* ochreous, greyish round eyes, with some dark hair, especially noticeable on the moderately large and somewhat bifid frontal tubercle. Front a little over a quarter as broad as head. Rostrum shorter than head, with broad rather long nasus. Antennae brownish-ochreous, tips of second and third joints pale. First scapal joint rather short, not much more than twice as long as the second. Flagellum with eight joints; first about three times as long as broad, second equally broad but rather shorter, third narrower and only about half as long as second; the remaining five all minute and together shorter than second and third together. Palpi not much longer than rostrum, brown; last joint not much longer than third. *Thorax* brownish, dusted with grey, except on the four somewhat shining dark reddish-brown praescutal stripes. Pronotum and interspaces of praescutum with some dark pubescence. *Abdomen* rather brightly shining, reddish-brown, apical portion of segment 2 and segments 3–5 darker. Segment 2 more than twice as long as segment 3. Pubescence rather spare, except on tergites 8 and 9, where it is shorter and much denser, and points forwards instead of backwards. Hypopygium as long as segments 6–8 together and slightly broader; ninth tergite considerably narrower than side-pieces, and only half as long, with a small median V-shaped emargination, corners somewhat produced; claspers large, reaching back over margin of ninth tergite, short-haired, without strong spines, an upper

flattened lobe covering a lower narrower ones. *Legs* rather stout, ochreous-brown, tips of femora and tibiae and last two or three tarsal joints blackish. Last tarsal joint cylindrical, unmodified. *Wings* with slight brown tinge, more obvious in costal cell; stigma shortly oval, dark brown. Sc_1 present, oblique (as in several species of *Macromastix*). Rs very short, curved, slightly longer than R_{2+3}, which is only half as long again as R_2; *r* meeting R_2 near the middle; stem of cell M_1 about one-third as long as cell; cell Ax rather narrow, of even width throughout. Halteres rather light brown. *Length* of body, 13 mm.; wing, 18 mm.; hind leg—femur 10 mm., tibia 10·5 mm., tarsus 20 mm.

♀. Differs from the male as follows: Front slightly broader, quite one-third as broad as head. Antennae further reduced, flagellum club-shaped, very narrow at base, hardly any longer than scape, composed of five indistinctly separated joints, of which first is as long as the other four together. Thorax narrow, no broader than base of abdomen, dark brown, unstriped, with hardly any grey dusting. Abdomen blackish, except towards tip, second segment not much longer than third. Ovipositor long and horny; anal valves straight, stout, with rounded tips, longer than rather long anal segment; genital valves also long, straight, reaching beyond middle of anal valves. Legs much shorter, stouter, with slightly longer pubescence; front femora somewhat stouter than others. Wings reduced to narrow rudiments. Halteres blackish, twisted, apparently in the first stage of degeneration. *Length* of body, 16 mm.; wing, 2 mm.; hind leg—femur 5 mm., tibia 5·2 mm., tarsus 5·5 mm.

North Island: Wellington district, April–May (*G. V. Hudson*, No. 170).

The male bears a rather striking resemblance to *Macromastix zeylandiae* Alexander, and it is not at all surprising that Hutton should have considered the two as varieties of one species. *H. heterogama* may be a development from this group of *Macromastix*.

Plate 27.

Fig.
1. *Anisopus notatus* (Hutton), ♂. × 6.
2. *Anisopus notatus* (Hutton), ♀. × 6. (From Lamb's type of *Rhyphus undulatus*.)
3. *Anisopus neozelandicus* (Schiner), ♀. × 6.
4. *Tanyderus annuliferus* Hutton, ♂. × 3.
5. *Tanyderus annuliferus* Hutton, ♀. × 3.
6. *Tanyderus neptunus* n. sp., ♂. × 3.
7. *Tanyderus forcipatus* O.-S., ♀. × 3.
8. *Tanyderus varipes* n. sp., ♂. × 3.
9. *Tanyderus varipes* n. sp., ♀. × 3.
10. *Dicranomyia flavidipennis* n. sp., ♂. × 5.
11. *Dicranomyia sublacteata* n. sp., ♂. × 5.
12. *Dicranomyia decincta* n. sp., ♂. × 5.
13. *Dicranomyia melanogramma* n. sp., ♂. × 5.
14. *Dicranomyia cubitalis* n. sp., ♂. × 5.
15. *Dicranomyia huttoni* n. name, ♂. × 5.
16. *Dicranomyia crassipes* n. sp., ♀. × 5.
17. *Dicranomyia repanda* n. sp., ♂. × 3.
18. *Dicranomyia fumipennis* (Butler), ♀. × 3.
19. *Dicranomyia hudsoni* n. sp., ♂. × 3.
20. *Dicranomyia tenebrosa*, n. sp., ♀. × 3.
21. *Dicranomyia conulifera* n. sp., ♀. × 5.
22. *Dicranomyia aegrotans* n. sp., ♀. × 6.
23. *Dicranomyia conveniens* (Walker), ♂. × 6.
24. *Dicranomyia luteonitens* n. sp., ♂. × 6.
25. *Dicranomyia gracilis* n. sp., ♂. × 6.

Face p. 352.]

Plate 28.

Fig.

26. *Discobola ampla* (Hutton), ♂. × 3.
27. *Discobola dohrni* O.-S., ♀. × 3.
28. *Discobola dicycla* n. sp., ♀. × 3.
29. *Discobola gibbera* n. sp., ♀. × 3.
30. *Discobola venusta* (O.-S.), ♂. × 3.
31. *Discobola picta* (Hutton), ♀. × 3.
32. *Discobola striata* n. sp., ♂. × 3.
33. *Discobola tesselata* (O.-S.), ♂. × 3. (From the type.)
34. *Discobola tesselata* O.-S., ♀. × 5.
35. *Elephantomyia zealandica* n. sp., ♀. × 6.
36. *Ceratocheilus levis* (Hutton), ♀. × 6.
37. *Ceratocheilus ochraceum* n. sp., ♂. × 6.
38. *Gonomyia* (*Lipophleps*) *nigrohalterata* n. sp., ♀. × 6.
39. *Amphineurus insulsus* (Hutton), ♀. × 6.
40. *Amphineurus fatuus* (Hutton), ♀. × 6.
41. *Amphineurus perdecorus* n. sp., ♂. × 6. (Denuded wing, to show venation.)
42. *Amphineurus perdecorus* n. sp., ♂. × 2·5. (Showing markings.)
43. *Amphineurus hudsoni* n. sp., ♀. × 5.
44. *Amphineurus horni* n. sp., ♀. × 9.
45. *Molophilus pulcherrimus* n. sp., ♀. × 9.
46. *Molophilus variegatus* n. sp., ♂. × 9.
47. *Gnophomyia* (*Aphrophila*) *neozelandica* n. sp., ♀. × 3.
48. *Gnophomyia* (*Astelobia*) *rufa* (Hudson). × 3.

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Plate 29.

Fig.
49. *Orolimnophila eluta* n. sp., ♂. × 3.
50. *Tinemyia margaritifera* Hutton, ♂. × 3.
51. *Rhamphophila* (n. gen.) *obscuripennis* (Hudson), ♂. × 3.
52. *Rhamphophila lyrifera* n. sp., ♂. × 2.
53. *Ulomorpha nebulosa* n. sp., ♂. × 3.
54. *Ulomorpha fuscana* n. sp., ♂. × 7.
55. *Limnophila leucomelas* n. sp., ♂. × 7.
56. *Limnophila hudsoni* n. sp., ♂. × 3.
57. *Limnophila marshalli* Hutton, ♂. × 3.
58. *Limnophila chrysorrhoea* n. sp., ♂. × 3.
59. *Limnophila nigrocincta* n. sp., ♀. × 3.

Fig.
60. *Limnophila cyatheti* n. sp., ♂. × 2.
61. *Limnophila geographica* Hutton, ♂. × 3.
62. *Limnophila crassipes* Hutton. × 2.
63. *Limnophila oculata* n. sp., ♂. × 2.
64. *Limnophila lambi* n. sp., ♂. × 3.
65. *Limnophila argus* Hutton, ♀. × 3.
66. *Limnophila delicatula* Hutton, ♀. × 3.
67. *Limnophila subinterventa* n. sp., ♀. × 3.
68. *Limnophila skusei* Hutton, ♂. × 2.
69. *Limnophila skusei* Hutton var., ♂. × 3.
70. *Limnophila skusei* Hutton var., ♀. × 3.

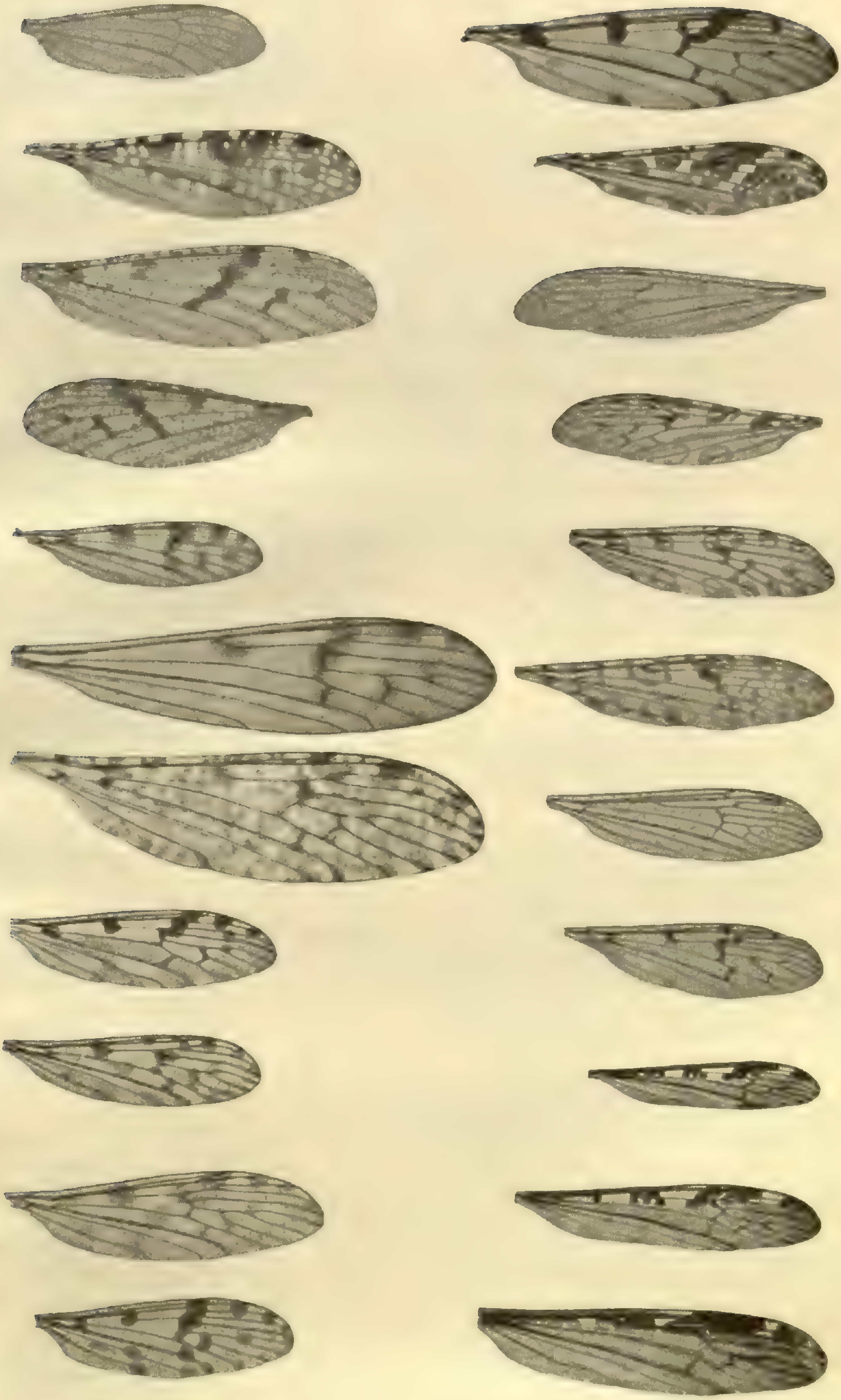

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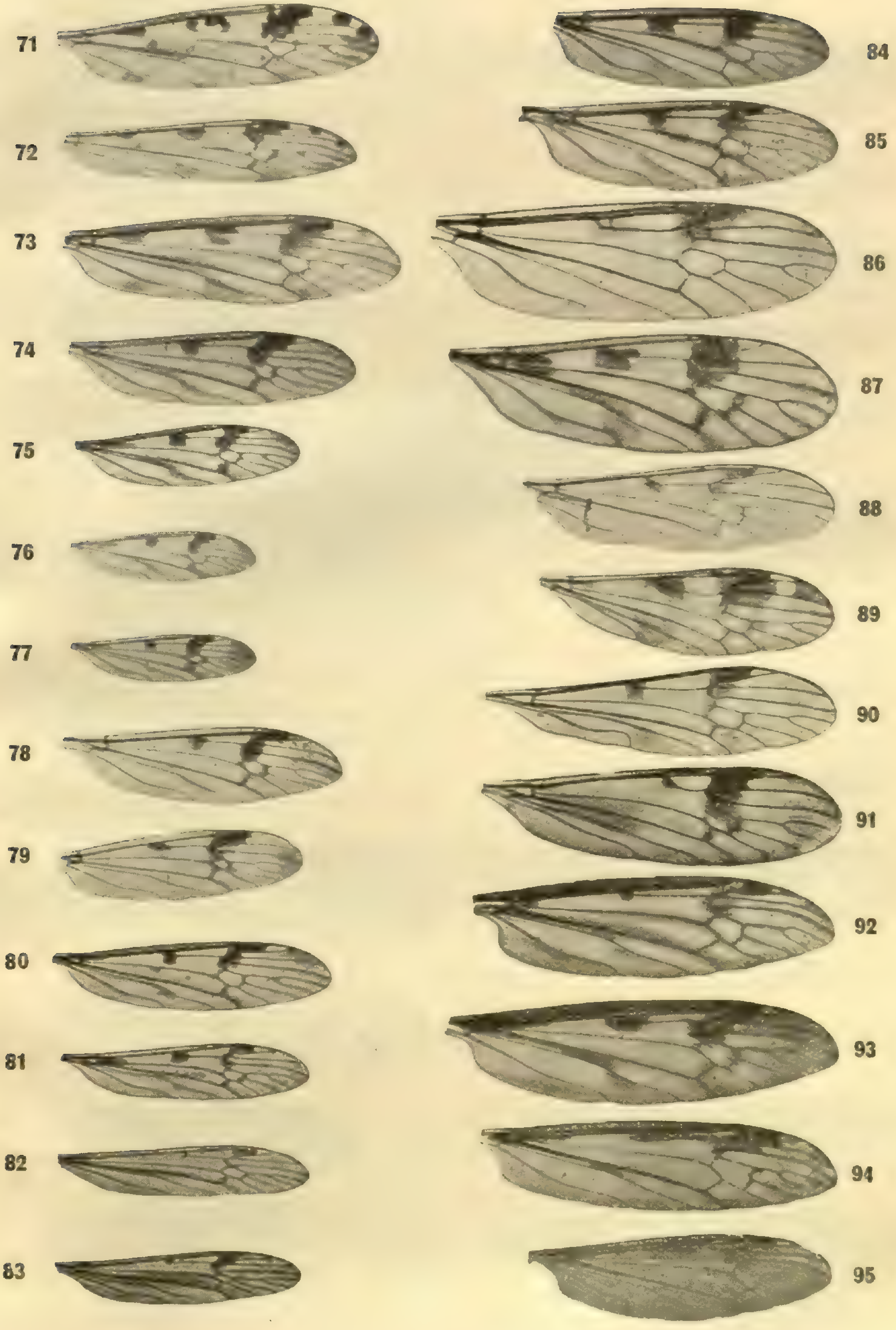
Plate 30.

Fig.

71. *Gynoplistia magnifica* n. sp., ♂. × 3.
72. *Gynoplistia notata* n. sp., ♂. × 3.
73. *Gynoplistia nebulosa* n. sp., ♂. × 3.
74. *Gynoplistia subfasciata* Walk., ♀. × 3. (From Walker's type.)
75. *Gynoplistia arthuriana* n. sp., ♀. × 3.
76. *Gynoplistia canterburiana* n. sp., ♀. × 2.
77. *Gynoplistia fimbriata* Alex., ♂. × 2.
78. *Gynoplistia tridactyla* n. sp., ♀. × 3.
79. *Gynoplistia speciosa* n. sp., ♀. × 3.
80. *Gynoplistia sackeni* Alex., ♂. × 3.
81. *Gynoplistia wakefieldi* Westw., ♂. × 3.
82. *Gynoplistia conjuncta* n. sp., ♂. × 3.
83. *Gynophistia bona* Alex., ♀. × 3.

Fig.

84. *Gynoplistia cuprea* Hutton var., ♂. × 3.
85. *Gynoplistia cuprea* Hutton, ♀. × 3.
86. *Gynoplistia violacea* n. sp., ♂. × 5.
87. *Gynoplistia nigronitida* n. sp., ♂. × 7.
88. *Gynoplistia polita* n. sp., ♂. × 5.
89. *Gynoplistia trifasciata* n. sp., ♂. × 7.
90. *Gynoplistia clavipes* n. sp., ♂. × 7.
91. *Gynoplistia albicincta* n. sp., ♀. × 7.
92. *Cerozodia plumosa* O.-S., ♂. × 2. (From Osten-Sacken's type.)
93. *Cerozodia paradisea* n. sp., ♂. × 2.
94. *Cerozodia pulverulenta* n. sp., ♂. × 2.
95. *Cerozodia hudsoni* n. sp., ♂. × 2.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Inset.

Plate 31.

Fig.
96. *Dolichopeza parvicauda* n. sp., ♂. × 3.
97. *Holorusia novarae* (Schin.), ♀. × 2. (Slight development of stump in cell M.)
98. *Holorusia novarae* (Schin.), ♂. × 2. (Complete cross-vein in cell M.)
99. *Holorusia fulva* (Hutton), ♂. × 2.
100. *Longurio dux* (Hudson), ♂. × 2.
101. *Longurio legatus* n. sp., ♂. × 2.
102. *Macromastix aperta* n. sp., ♂. × 2.
103. *Macromastix clara* (Kirby), ♂. × 2.
104. *Macromastix maori* Alex., ♂. × 2·5. (From Alexander's type.)
105. *Macromastix binotata* Hutton, ♂. × 3.
106. *Macromastix lunata* Hutton, ♂. × 3.
107. *Macromastix variegata* n. sp., ♂. × 3.
108. *Macromastix decorata* n. sp., ♂. × 3.
109. *Macromastix huttoni* n. sp., ♂. × 3.
110. *Macromastix vittata* n. sp., ♂. × 3.

Fig.
111. *Macromastix alexanderi* n. sp., ♂. × 2.
112. *Macromastix fumibasis* n. sp., ♂. × 2.
113. *Macromastix cubitalis* n. sp., ♀. × 3.
114. *Macromastix albistigma* n. sp., ♀. × 2. (A pale specimen.)
115. *Macromastix obliqua* n. sp., ♂. × 2.
116. *Macromastix vulpina* (Hutton), ♂. × 2.
117. *Macromastix rufiventris* n. sp., ♂. × 2.
118. *Macromastix minor* n. sp., ♂. × 2.
119. *Macromastix dichroithorax* Alex., ♀. × 2.
120. *Macromastix sinclairi* n. sp., ♀. × 2.
121. *Macromastix zeylandiae* Alex., ♂. × 3.
122. *Hudsonia heterogama* (Hudson), ♂. × 3.

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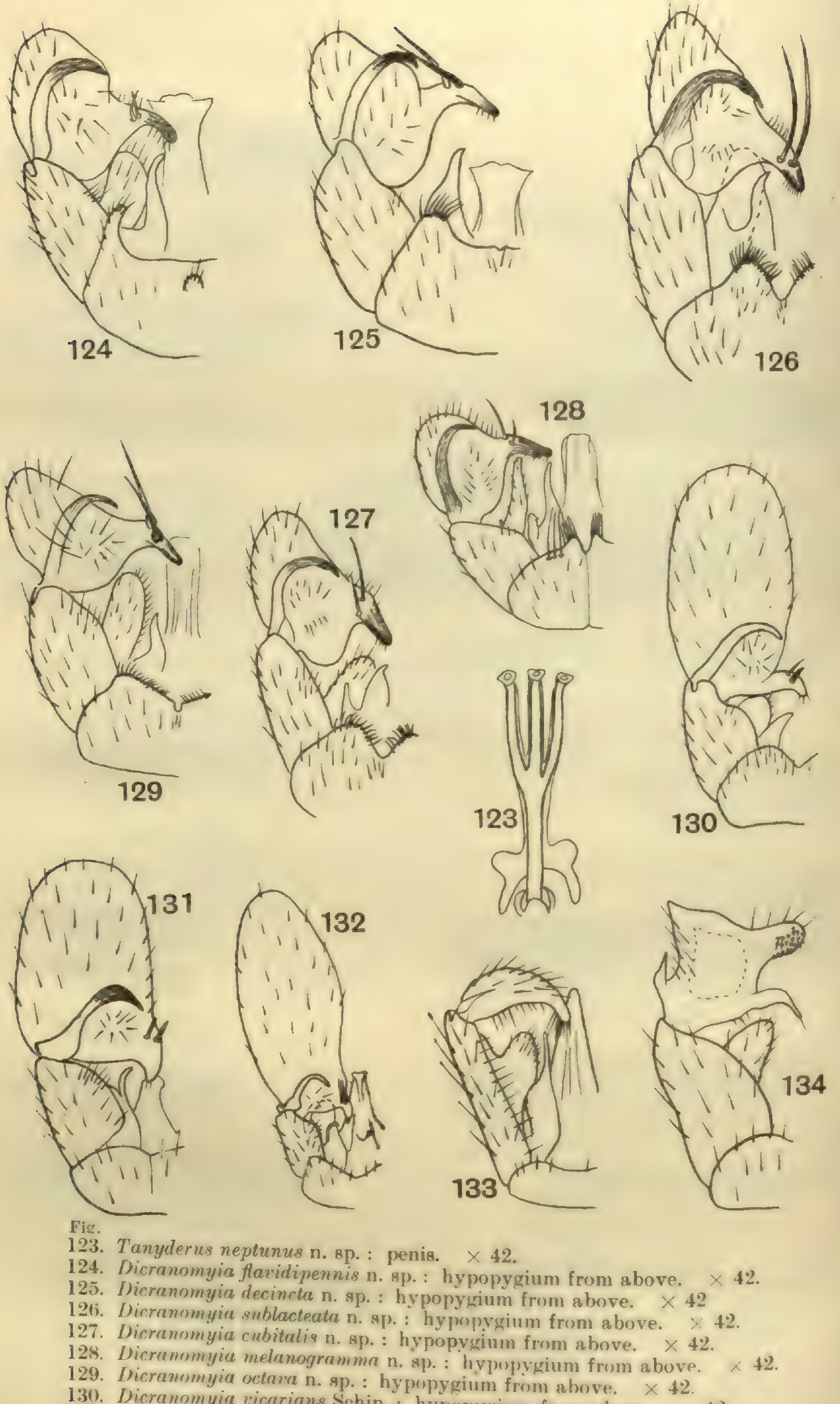

Fig.
123. *Tanyderus neptunus* n. sp. : penis. × 42.
124. *Dicranomyia flavidipennis* n. sp. : hypopygium from above. × 42.
125. *Dicranomyia decincta* n. sp. : hypopygium from above. × 42
126. *Dicranomyia sublacteata* n. sp. : hypopygium from above. × 42.
127. *Dicranomyia cubitalis* n. sp. : hypopygium from above. × 42.
128. *Dicranomyia melanogramma* n. sp. : hypopygium from above. × 42.
129. *Dicranomyia octava* n. sp. : hypopygium from above. × 42.
130. *Dicranomyia vicarians* Schin. : hypopygium from above. × 42.
131. *Dicranomyia conveniens* (Walk.) : hypopygium from above. × 42.
132. *Dicranomyia sulphuralis* n. sp. : hypopygium from above. × 42.
133. *Dicranomyia gracilis* n. sp. : hypopygium from above. × 42.
134. *Discobola striata* n. sp. : hypopygium from above. × 42.

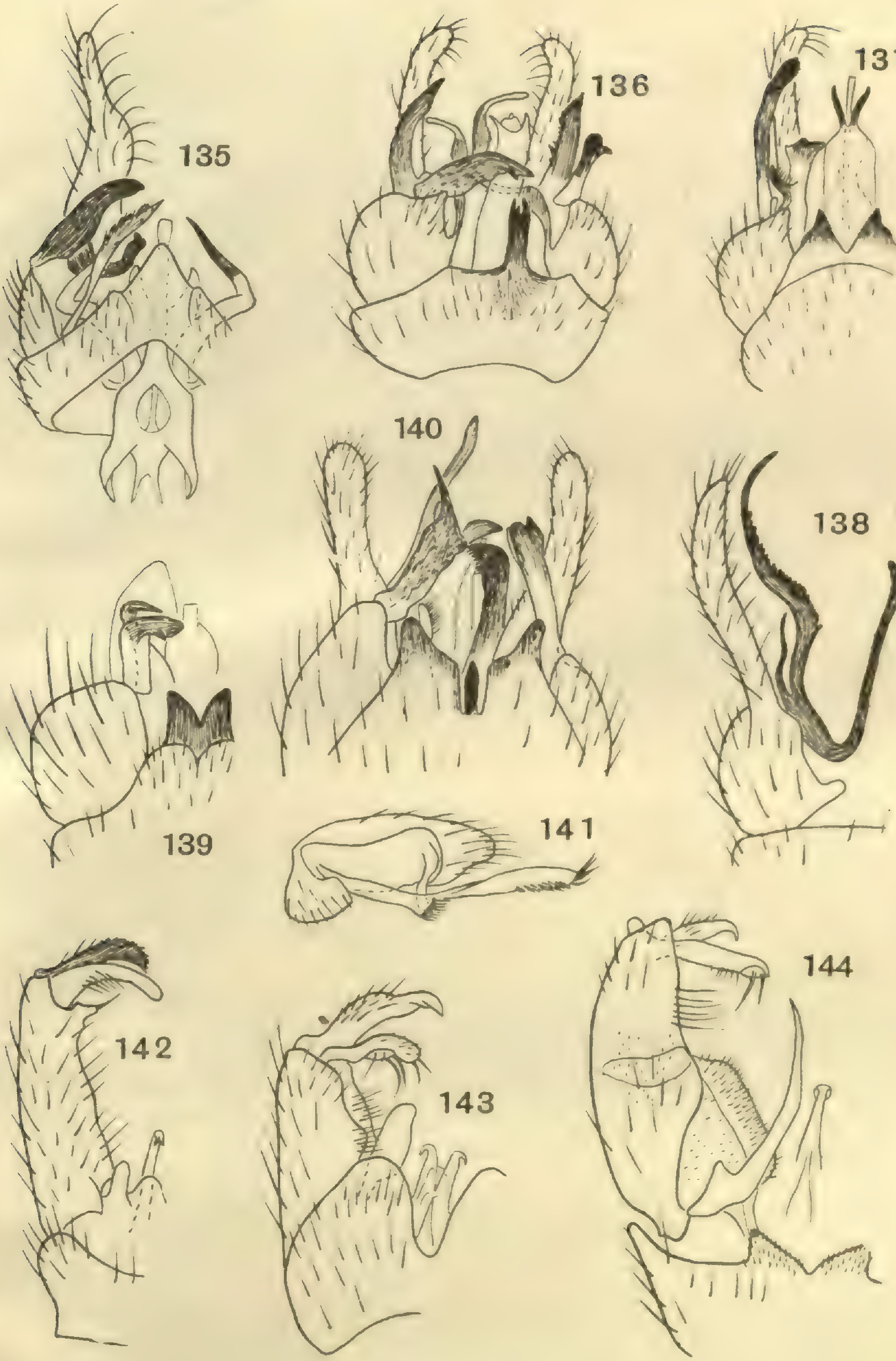

Fig.
135. *Amphineurus perdecorus* n. sp. : hypopygium from below (tergal view). × 42.
136. *Amphineurus bicinctus* n. sp. : hypopygium from below (tergal view). × 42.
137. *Amphineurus hudsoni* n. sp. : hypopygium from below (tergal view). × 42.
138. *Amphineurus insulsus* (Hutton) : hypopygium from above (sternal view). × 42.
139. *Amphineurus insulsus* (Hutton) : hypopygium from below (tergal view). × 42.
140. *Amphineurus fatuus* (Hutton) : hypopygium from below (tergal view). × 42.
141. *Molophilus inornatus* n. sp. : side-piece and claspers from inner side. × 42.
142. *Orolimnophila eluta* n sp. : hypopygium from above. × 42.
143. *Ulomorpha nebulosa* n. sp. : hypopygium from above. × 42.
144. *Tinemyia margaritifera* Hutton : hypopygium from above. × 42.

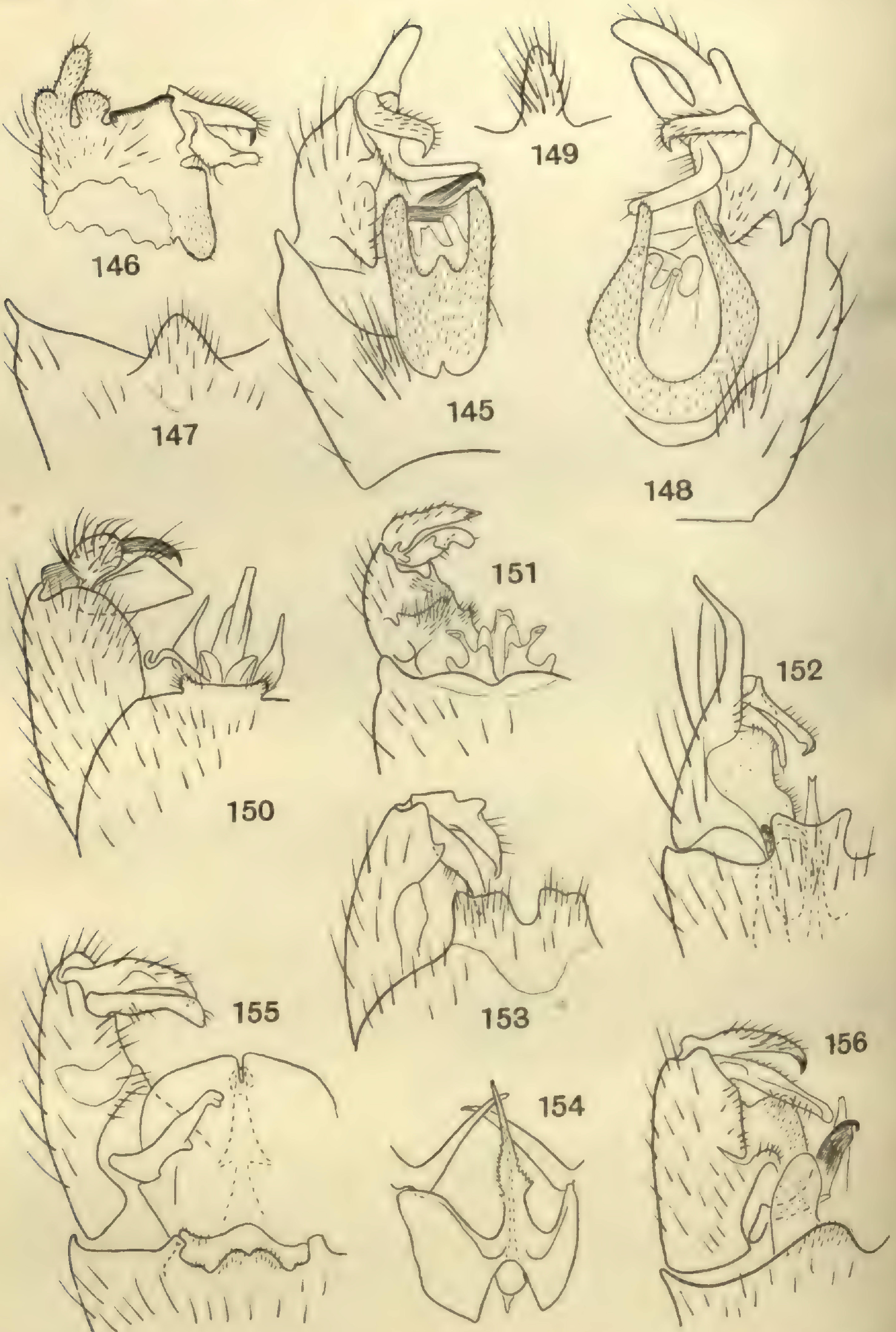

Fig.
145. *Rhamphophila obscuripennis* (Huds.): hypopygium from below. × 27.
146. *Rhamphophila obscuripennis* (Huds.): side-piece from inner side. × 27.
147. *Rhamphophila obscuripennis* (Huds.): apex of ninth tergite. × 27
148. *Rhamphophila lyrifera* n. sp.: hypopygium from below. × 27.
149. *Rhamphophila lyrifera* n. sp.: process of ninth tergite. × 27.
150. *Limnophila skusei* Hutton: hypopygium from above. × 42.
151. *Limnophila delicatula* Hutton: hypopygium from above. × 42.
152. *Limnophila leucomelas* n. sp.: hypopygium from above. × 42.
153. *Limnophila subinterventa* n. sp.: hypopygium from above. × 42.
154. *Limnophila subinterventa* n. sp.: aedoeagus from above. × 42.
155. *Limnophila geographica* Hutton: hypopygium from above. × 42.
156. *Limnophila oculata* n. sp.: hypopygium from above. × 27.

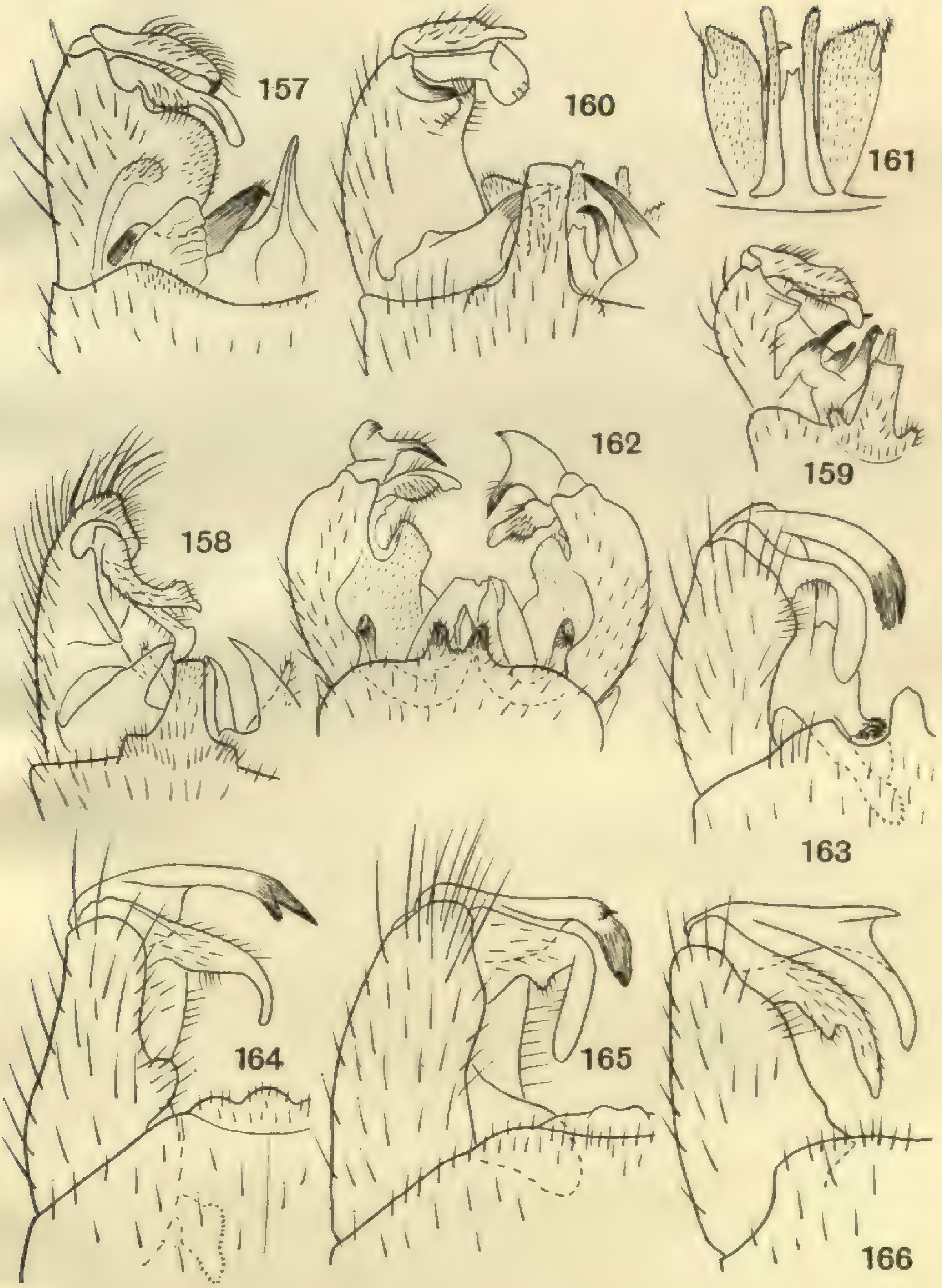

Fig.
157. *Limnophila lambi* n. sp : hypopygium from above. × 42.
158. *Limnophila chrysorrhoea* n. sp. : hypopygium from above. × 27.
159. *Limnophila marshalli* Hutton : hypopygium from above. × 42.
160. *Limnophila cyatheti* n. sp. : hypopygium from above. × 27.
161. *Limnophila cyatheti* n. sp. : basal lobes of side-pieces from below. × 27.
162. *Limnophila hudsoni* n. sp. : hypopygium from above. × 27.
163. *Gynoplistia subfasciata* Walk. : hypopygium from above. × 42.
164. *Gynoplistia glauca* n. sp. : hypopygium from above. × 42.
165. *Gynoplistia fuscoplumbea* n. sp. : hypopygium from above. × 42.
166. *Gynoplistia incisa* n. sp. : hypopygium from above. × 42.

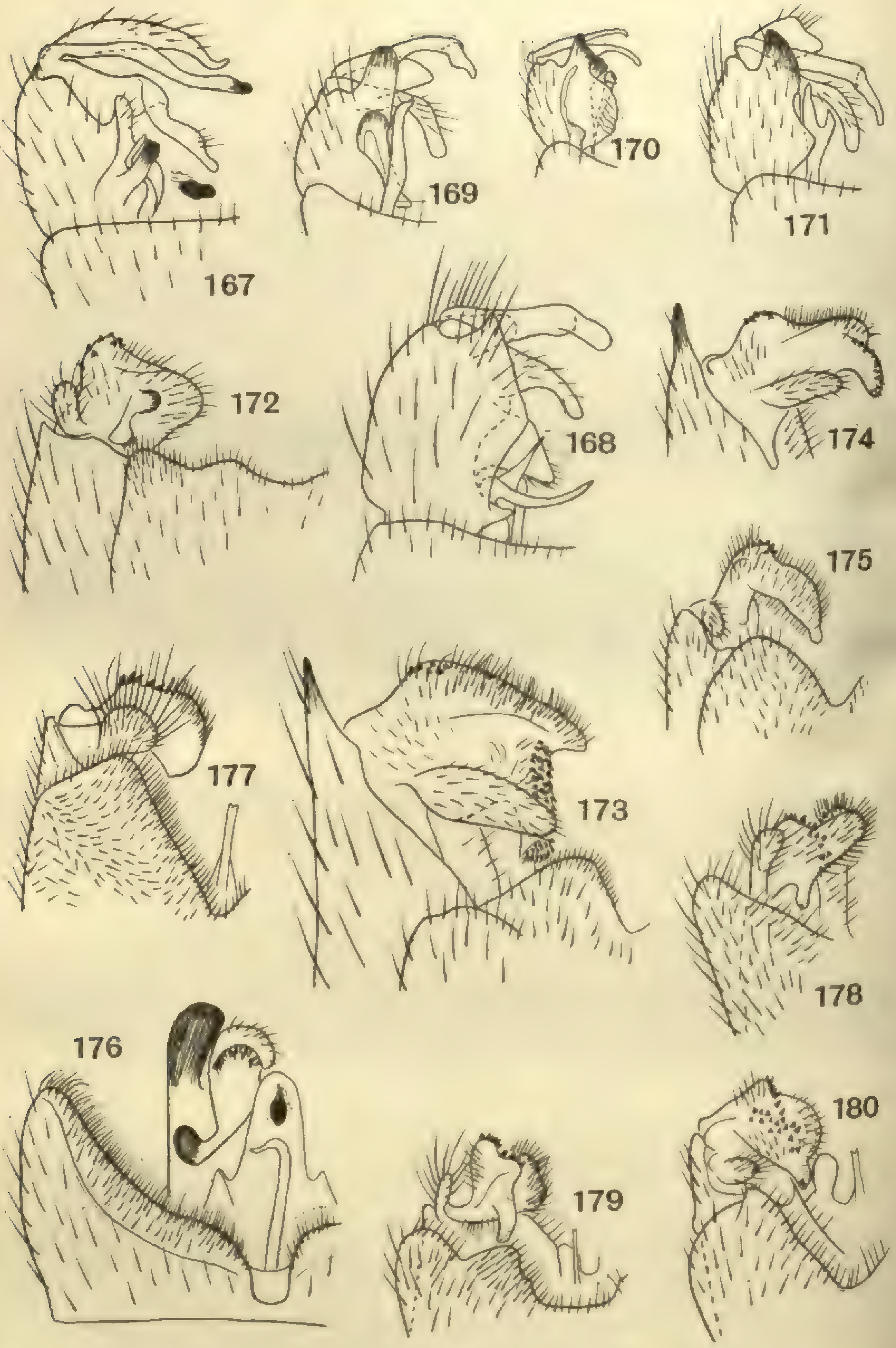

Fig.
167. *Gynoplistia tridactyla* n. sp.
168. *Gynoplistia violacea* n. sp.
169. *Gynoplistia clavipes* n. sp.
170. *Gynoplistia trifasciata* n. sp.
171. *Gynoplistia polita* n. sp.
172. *Macromastix virescens* n. sp.
173. *Macromastix viridis* (Walk.).

Fig.
174. *Macromastix albistigma* n. sp.
175. *Macromastix holochlora* (Now.).
176. *Macromastix obliqua* n. sp.
177. *Macromastix zeylandiae* Alex.
178. *Macromastix dichroithorax* Alex.
179. *Macromastix sinclairi* n. sp.
180. *Macromastix obscuripennis* (Kirby).

Hypopygium from above. × 42.

ART. 28.—*An Index of New Zealand Beetles.*

By G. V. HUDSON, F.E.S., F.N.Z.Inst.

[*Read before the Wellington Philosophical Society, 7th December, 1921; received by Editor, 20th October, 1921; issued separately, 30th April, 1923.*]

I HAVE undertaken the preparation of the following index, which is outside the scope of my usual entomological work, under the conviction that such an index is urgently required, and is not otherwise likely to be compiled. It is perhaps desirable for me to state that the list is simply a systematic index. It is neither a revision nor a synonymic list. No doubt a properly revised synonymic list of our Coleoptera is a great desideratum at the present time, but the production of such a list would require a much fuller knowledge of our beetles than I can claim to possess, and must, so far as I can see, be left to some future worker. In the meantime the present list may be regarded as a preliminary step. It will assist collectors in arranging their collections, and will enable them to refer to a description of any species they may desire to consult.

The list of Coleoptera contained in Captain Hutton's invaluable *Index Faunae Novae Zealandiae* is now very much out of date, over 1,400 species having been described by the late Major Broun since that work was published in 1904. Captain Hutton's list was prepared by Major Broun himself, and I have assumed that it is a complete index up to the end of the year 1903. In compiling the following list I have consulted all available publications issued subsequent to that date, and in this way have endeavoured to attain a measure of completeness. In the course of my work I have found that certain species mentioned in Major Broun's *Manual of New Zealand Coleoptera* do not appear in Captain Hutton's list; and, unless these species are mentioned in publications *later* than Hutton's index, I have not inserted them, as I assume that Major Broun must have regarded them as synonyms and intentionally omitted them.

The scheme of the classification followed in my index is that in general use in England at the present time. It is regarded as a more natural and satisfactory system than that contained in the *Cambridge Natural History*, which formed the basis of Captain Hutton's list. For assistance and advice in connection with this part of my work I am much indebted to my kind friend Commander J. J. Walker. Within each family I have arranged the genera, as far as possible, in accordance with the views expressed in Major Broun's publications.

As regards the question of synonymy, it should be stated at the outset that Major Broun is not responsible for the creation of anything like the number of synonyms that some of his critics have assumed. The coleopterous fauna of New Zealand is undoubtedly a very rich one, and, like the Lepidoptera, contains a very large proportion of difficult forms whose slight and elusive differences are extremely difficult to appreciate. The whole subject of synonymy is, however, very slightly touched upon in Major Broun's works, and it certainly appears probable that some of the descriptions contained in the very early publications may relate to insects which have been renamed and redescribed in later publications. For example, *Uloma tenebrionides* White and *Uloma laevicostata* Blanchard

may be names referring to the same species, and this may also apply to *Teramocerus barbicornis* Fabricius and *Teramocerus cylindricornis* Fabricius. These and similar questions can only be settled by reference to the original types. Again, Major Broun repeatedly states he has not seen the types of certain species described by Dr. Sharp and other authors, and it would appear likely that a certain amount of synonymy may have resulted in at least some of these cases. Furthermore, it is noteworthy that Major Broun has described a great number of species from single specimens, and in these cases the question of possible intermediate forms connecting some of the species cannot have been fully taken into account.

I am much indebted to the Hon. G. M. Thomson, M.L.C., for a list of the introduced beetles. These have, as far as possible, been inserted in systematic order. They are in every case distinguished by an asterisk placed before the name of each species.

Beetles found in the Kermadec Islands which do not also occur in New Zealand are not included in the index.

In referring to so many scattered publications, extending over a period of nearly twenty years, it is inevitable that some errors and omissions have occurred, and in this connection I must ask for the kind indulgence of all those who may use the index.

Abbreviations.

A. *Annals and Magazine of Natural History.*
B. *Bulletin, New Zealand Institute.*
C. *Manual of New Zealand Coleoptera, 1880–93.*
E. *Transactions of the Entomological Society of London.*
S. *Subantarctic Islands of New Zealand.*
T. *Transactions of the New Zealand Institute.*

Order COLEOPTERA.

Group GEODEPHAGA.

Family CICINDELIDAE.

Cicindela Linnaeus, 1735.
tuberculata Fabricius. C. 2.
huttoni Broun. C. 2.
laticincta White. C. 3.
wakefieldi Bates. C. 3.
douei Chenu. C. 3.
parryi White. C. 4.
dunedinensis Castelnau. C. 4.
feredayi Bates. C. 4.
austromontana Bates. C. 5.
perhispida Broun. C. 4.
campbelli Broun. C. 817.
helmsi Sharp. C. 975.
incognita Horn. *Deutsche Ent. Zeit.*, 1892, 82.
novaseelandica Horn. *Deutsche Ent. Zeit.*, 1892, 83.
circumpictoides Horn. *Deutsche Ent. Zeit.*, 1900, 207.
waiouruensis Broun. B. 1, iii, 146.
halli Broun. B. 1, v, 350.
hamiltoni Broun. B. 1, vii, 594.
ezonata Broun. B. 1, vii, 594.

Family CARABIDAE.

Subfamily Migadopinae.

Amarotypus Bates, 1872.
edwardsi Bates. C. 6.

Subfamily Scarilinae.

Clivina Latreille, 1810.
rugithorax Putzeys. C. 7.

Subfamily Cnemacanthinae.

Mecodema Blanchard, 1853.
sculpturatum Blanchard. C. 8.
howittii Castelnau. C. 8.
rectolineatum Castelnau. C. 8.
impressum Castelnau. C. 9.
lucidum Castelnau. C. 9.
crenicolle Castelnau. C. 9.
simplex Castelnau. C. 9.
alternans Castelnau. C. 10.
crenaticolle Redtenbacher. C. 10.
spinifer Broun. C. 10.
fulgidum Broun. C. 653.
constrictum Broun. C. 653.

Group GEODEPHAGA—*continued.*

Mecodema—continued.
rugicolle Broun. C. 745.
venator Broun. C. 817.
litoreum Broun. C. 875.
ducale Sharp. C. 976.
rugiceps Sharp. C. 976.
metallicum Sharp. C. 977.
suteri Broun. C. 977.
scitulum Broun. A. 6, xiv, 302.
lineatum Broun. A. 6, xiv, 303.
punctifer Broun. C. 745.
aeneoniger Broun. C. 818.
bullatum Lewis. T. xxxiv, 202.
infimate Lewis. T. xxxiv, 202.
laeviceps Broun. A. 7, xiv, 41.
striatum Broun. A. 7. xiv, 42.
walkeri Broun. A. 7, xiv, 43.
costellum Broun. A. 7, xi, 451.
intricatum Broun. A. 7, xi, 451.
nitidum Broun. A. 7, xi, 452.
variolosum Broun. A. 7, xi, 453.
costipenne Broun. B. 1, ii, 82.
angustulum Broun. B. 1, ii, 82.
dissonum Broun. B. 1, ii, 83.
acuductum Broun. A. 8, ii, 335.
cognatum Broun. A. 8, ii, 336.
lewisi Broun. A. 8, ii, 337.
seriatum Broun. A. 8, ii, 338.
attenuatum Broun. A. 8, ii, 339.
puncticolle Broun. B. 1, iii, 146.
halli Broun. B. 1, iv, 270.
huttense Broun. B. 1. iv, 270.
persculptum Broun. B. 1, iv, 271.
ambiguum Broun. B. 1, iv, 272.
laterale Broun. B. 1, v, 350.
chiltoni Broun. B 1, v, 351.
politanum Broun. B. 1, v, 352.
rubripes Broun. B. 1, v, 353.
erraticum Broun. B. 1, v, 353.
gratum Broun. B. 1, v, 354.
latulum Broun. B. 1, v, 355.
affinum Broun. B. 1, v, 355.
indiscretum Broun. B. 1, v, 356.
trailli Broun. B. 1, v, 356.
mutabile Broun. B. 1, v, 357.
gordonense Broun. B. 1, v, 357.
o'connori Broun. T. xliv, 382.
bryobium Broun. T. xliv, 383.
laevicolle Broun. T. xliv, 384.
quoinense Broun. T. xliv, 384.
arcuatum Broun. T. xliv, 385.
hudsoni Broun. S. 83.
femorale Broun. B. 1, vii, 595.
veratrum Broun. B. 1, vii, 596.
punctellum Broun. B. 1, vii, 596.
insulare Broun. B. 1, vii, 597.
validum Broun. B. 1, viii, 670.
occiputale Broun. B. 1, viii, 670.
cassense Broun. B. 1, viii, 671.
antennale Broun. B. 1, viii, 672.
longicolle Broun. B. 1, viii, 672.
philpotti Broun. B. 1, viii, 672.
ventriculum Broun. B. 1, viii, 673.
subaeneum Broun. B. 1, viii, 674.

Metaglymma Bates, 1867.
tibiale Castlenau. C. 11.
monilifer Bates. C. 11.
punctatum Putzeys. C. 11.
morio Castelnau. C. 11.
elongatum Castelnau. C. 12.
aberrans Putzeys. C. 12.
dyschirioides Castelnau. C. 12.
oblongum Broun. C. 746.
asperum Broun. C. 978.
junctum Broun. C. 979.
sulcatum Sharp. C. 979.
tersatum Broun. C. 980.
rugipenne Broun. C. 1321.
thoracicum Broun. C. 1322.
modicum Broun. A. 6, xiv, 305.
oregoide Broun. A. 6, xiv. 305.
rufipes Broun. C. 876.
rugiceps Broun. A. 7, xi, 454.
calcaratum Broun. A. 7, xi, 455.
doullii Broun. A. 7, xv, 543.
minor Broun. A. 7, xv, 543.
ovicolle Broun. B. 1, iii, 147.
currideus Broun. B. 1, iv, 273.
Oregus Putzeys, 1868.
aereus White. C. 13.
inaequalis Castelnau. C. 13.
Brullea Castelnau, 1867.
antarctica Castelnau. C. 14.
Diglymma Sharp, 1886.
ovipenne Sharp. C. 981.
dubium Sharp. C. 981.
punctipenne Broun. C. 982.
nigripes Broun. C. 982.
obtusum Broun. C. 819.
clivinoides Castelnau. C. 12.
tarsalis Broun. A. 8, ii, 340.
marginale Broun. B. 1, iii, 148.
basale Broun. B. 1, v, 358.
thoracicum Broun. B. 1, v, 359.
castigatum Broun. S. 84.
Snofru Broun, 1908.
aemulator Broun. A. 8, ii, 341.
Acallistus Sharp, 1886.
simplex Sharp. C. 983.

Subfamily LICININAE.

Rembus Latreille, 1822.
zeelandicus Redtenbacher. C. 15.
Physolaesthus Chaudoir, 1850.
insularis Bates. C. 15.
limbatus Bates. C. 17.
Dichrochile Guérin, 1846.
subopaca Bates. C. 16.
blavipes Broun. B. 1, v, 360.
aterrima Bates. C. 16.
ovicollis Motschulsky. C. 16.
maura Broun. C. 18.
nitida Broun. C. 746.
cinctiger Broun. C. 747.
cephalotes Broun. A. 6, xiv, 306.
fabrei Guérin. *Ann. Fr.* 1846, *Bull.*, 103.

Group GEODEPHAGA—*continued.*

Dichrochile—continued.
anthracina Broun. A. 6, xii, 161.
cordicolle Broun. A. 7, xi, 455
thoracica Broun. A. 8, ii, 345.
insignis Broun. B. 1, v, 359.
rugicollis Broun. B. 1, v, 360.

Subfamily Anchomeninae.

Calathus Bonelli, 1809.
rubromarginatus Blanchard. S. 96.
Anchomenus Bonelli, 1809.
novae-zealandiae Fairmaire. *Ann, Soc. Ent.*, 1843.
elevatus White. C. 21.
montivagus Broun. C. 22.
feredayi Bates. C. 23.
lawsoni Bates. C. 23.
submetallicus White. C. 24.
deplanatus White. C. 25.
colensonis White. C. 25.
otagoensis Bates. C. 25.
edwardsii Bates. C. 26.
sulcitarsis Broun. C. 27.
helmsi Sharp. C. 749.
haasti Broun. C. 747.
sandageri Broun. C. 748.
oreobius Broun. C. 876.
atratus Blanchard. *Voy. Pole. Sud*, iv, 21.
raptor Redtenbacher, *Reise Novara, Coleop.*, 18.
marginellus Erichson. *Archives*, 1842, 130.
walkeri Broun. A. 7, xi, 456.
libitus Broun. B. 1, ii, 84.
macrocaelis Broun. A. 8, ii, 346.
xanthomelas Broun. A. 8, ii, 346.
intermedius Broun. A. 8, ii, 347.
integratus Broun. A. 8, ii, 348
sophronitis Broun. A. 8, ii, 349.
chathamensis Broun. T. xli, 147.
arnaudensis Broun. B. 1, vii, 598.
hallianus Broun. B. 1, vii, 598.
Ctenognathus Fairmaire, 1843.
latipennis Sharp. C. 984.
parabilis Broun. C. 20.
politulus Broun. C. 20.
batesi Broun. C. 20.
deformipes Broun. C. 20.
cheesemani Broun. C. 20.
suborbithorax Broun. C. 20.
perrugithorax Broun. C. 20.
lucifugus Broun. C. 20.
adamsi Broun. C. 20.
pictonensis Sharp. C. 985.
bidens Chaudoir. *Ann. Soc. Ent. Fr.*, 1875, 303.
munroi Broun. C. 984.
actochares Broun. A. 6, xiv, 307.
novae-zealandiae Fairmaire. *Ann. Soc. Ent. Fr.*, 1843, 12.
neozealandicus Chaudoir. *Ann. Soc. Ent. Fr.*, 1875, 294.

Ctenognathus—continued.
crenatus Chaudoir. *Ann. Soc. Ent. Fr.*, 1875, 304.
cardiophorus Chaudoir. *Ann. Soc. Ent. Fr.*, 1875, 305.
macropterus Chaudoir. *Ann. Soc. Ent. Fr.*, 1875, 370.
littorellus Broun. A. 8, ii, 349.
simmondsi Broun. T. xliv, 386.
Pristancylus Blanchard, 1853.
brevis Blanchard. S. 95.
castaneus Blanchard. S. 95.
Pristonychus.
**terricola* Herbst.
Drimostoma Dejean, 1831.
antarctica Castelnau. C. 30.

Subfamily Feroninae.

Prosopogmus Chaudoir, 1865.
impressifrons Chaudoir. C. 30.
Trichosternus Chaudoir, 1865.
antarcticus Chaudoir. C. 31.
guerinii Chaudoir. C. 32.
capito White. C. 32.
sylvius Bates. C. 35.
aucklandicus Broun. C. 33.
difformipes Bates. C. 33.
lobipes Bates. C. 34.
temukensis Bates. C. 34.
rectangulus Chaudoir. C. 35.
planiusculus White. C. 36.
humeralis Broun. C. 750.
enysi Broun. C. 752.
cephalotes Broun. C. 825.
alternus Broun. C. 877.
urquharti Broun. C. 877.
virens Broun. C. 937.
compressus Sharp. C. 987.
polychaetus Broun. C. 987.
smithii Broun. C. 1322.
hampdenensis Broun. C. 1323.
crassalis Broun. C. 1395.
walkeri Broun. A. 7, xi, 602.
akaroensis Broun. A. 7, xi, 603.
bucolicus Broun. A. 7, xi, 604.
rectalis Broun. C. 1146.
haplopus Broun. C. 1323.
hudsoni Broun. A. 7, xiv, 44.
dissentaneus Broun. B. 1, i, 6.
coelocephalus Broun. A. 8, ii, 405.
hanmerensis Broun. A. 8, ii, 406.
ordinarius Broun. A. 8, ii, 407.
halli Broun. B. 1, iii, 149.
blandellus Broun. B. 1, iv, 274.
wallacei Broun. T. xliv, 390.
Zeopoecilus Sharp, 1886.
calcaratus Sharp. C. 989.
achilles Sharp. C. 990.
putus Broun. C. 750.
opulentus Broun. C. 820.
optandus Broun. A. 8, ii, 408.

Group GEODEPHAGA—*continued.*

Pterostichus Bonelli, 1809.

(Species like *Trichosternus*, but without prosternal setae.)

fultoni Broun. C. 751.
waihorensis Broun. C. 821.
monticola Broun. C. 821.
aeruginosus Broun. C. 822.
asperatus Broun. C. 822.
chloris Broun. C. 823.
grassator Broun. C. 823.
maiaei Broun. B. 1, v, 363.
amicus Broun. C. 824.
fusulus Broun. C. 824.
curvipes Broun. C. 878.
optabilis Broun. C. 913.
meritus Broun. C. 914.
angulatus Broun. C. 914.
meliusculus Broun. C. 915.
agriolis Broun. C. 915.
erraticus Broun. C. 915.
deceptus Broun. C. 916.
curtulus Broun. C. 916.
suspicax Broun. C. 917.
amplicollis Broun. C. 918.
sandageri Broun. C. 988.
haplopus Broun. C. 1323.
vagans Broun. C. 825.
dentiferus Broun. C. 36.
kirkianus Broun. A. 7, xi, 604.
memes Broun. A. 7, xi, 605.
prasignis Broun. A. 7, xi, 606.
setiventris Broun. A. 7, xi, 606.
oneroaensis Broun. A. 8, ii, 413.
flectipes Broun. A. 8, ii, 413.
fossalis Broun. B. 1, iii, 149.
pascoi Broun. B. 1, iv, 275.
aciphyllae Broun. B. 1, v, 361.
hamiltoni Broun. T. xliv, 390.

(Thorax with two setae on each side.)

prolixus Broun. C. 35.
integratus Bates. C. 40.
cavelli Broun. C. 991.
procerulus Broun. C. 827.
ovatellus Chaudoir. C. 39.
perbonus Broun. A. 8, ii, 418.
placidulus Broun. C. 658.
impiger Broun. C. 879.
mordax Broun. C. 938.
longiformis Sharp. C. 991.
sternalis Broun. C. 658.
oscillator Sharp. C. 995.
lepidulus Broun. A. 8, ii, 419.
perfidiosus Broun. C. 995.
hunuensis Broun. C. 996.
maorinus Bates. C. 41.
disparalis Broun. C. 1324.
edax Broun. C. 1326.
arduus Broun. C. 1395.
scitipennis Broun. C. 1396.
sharpianus Broun. A. 6, xii, 163.
chalmeri Broun. A. 8, ii, 420.
bullatus Broun. B. 1, iv, 275.
sculpturalis Broun. B. 1, v, 363.

Pterostichus—continued.
fenwicki Broun. B. 1, vii, 599.
truncatulus Broun. B. 1, viii, 674.

(Thorax with three setae on each side.)

elongellus White.

(Thorax with four setae on each side.)

hispidulus Broun. C. 40.
cribralis Broun. C. 752.
myrmidon Sharp. C. 993.
hybridus Broun. C. 826.
fieldi Broun. B. 1, iv, 276.
praecox Broun. C. 827.
burrowsi Broun. B. 1, iii, 150.
brounianus Sharp. C. 992.
constrictellus Sharp. C. 994.
detractus Broun. C. 996.
subaeneus Guérin. C. 38.
oedicnemus Bates. C. 39.
pastoricius Broun. C. 994.
inconstans Broun. C. 999.
philpotti Broun. A. 8, ii, 418.
egmontensis Broun. C. 997.
irregularis Broun. C. 998.
suteri Broun. C. 1324.
sinuellus Broun. C. 1325.
delator Broun. C. 1397.
rugifrons Sharp. C. 1397.
ithaginus Broun. A. 6, xii, 162.
obsoletus Broun. A. 6, xii, 163.
vexatus Broun. A. 8, ii, 417.
lewisi Broun. A. 6, xiv, 310.
turgidiceps Broun. A. 8, ii, 409.
odontellus Broun. A. 8, ii, 410.
antennalis Broun. A. 8, ii, 412.
oxymelus Broun. A. 8, ii, 415.
sinuiventris Broun. A. 8, ii, 416.

(Thorax with five or more setae on each side.)

catenulatus Broun. C. 753.
mucronatus Broun. C. 826.
insidiosus Broun. C. 999.
sculptipes Broun. C. 1325.
egregialis Broun. B. 1, v, 362.

(Species of doubtful position.)

thoracicus Broun. C. 657.
angustulus Chaudoir. C. 38.
sylvaticus Chaudoir. C. 38.
vigil White. C. 41.
politissima White. C. 41.
pellax White. C. 657.
reflexum Chaudoir. *Bull. Mosc.*, xxxviii, 74.
convexidorsis Tschitschérine. *Hor. En. Ross.*, 1891, 166.
adoxus Broun. A. 8, ii, 414.

Alogus Motschulsky, 1865.
monachicus Motschulsky. C. 44.

Cerabilia Castlenau, 1868.
maori Castlenau. C. 44.
punctigera Broun. C. 753.
ruficornis Broun. C. 754.

Group GEODEPHAGA—*continued.*

Rhytisternus Chaudoir, 1865.
rugifrons Broun. C. 41.
erythrognathus Broun. C. 986.
**puella* Chaudoir.
Steropus Megerle, 1821.
helmsi Sharp. C. 989.
Argutor Megerle, 1837.
erythropus Blanchard. C. 42.
piceus Blanchard. C. 43.
pantomelas Blanchard. *Voy. Pole Sud, Zool.*, iv, 27.
calathoides Broun. C. 879.

Subfamily ANISODACTYLINAE.

Triplosarus Bates, 1874.
fulvescens Bates. C. 45.
novae-zealandiae Castelnau. C. 659.
Loxomerus Chaudoir.
nebrioides Guérin. S. 92.
ambiguus Broun. S. 92.
fossulatus Broun. S. 93.
cilicollis Broun. S. 94.
huttoni Broun. S. 94.
Lecanomerus Chaudoir, 1850.
latimanus Bates. C. 45.
insignitus Broun. C. 47.
obesulus Bates. C. 47.
fuliginosus Broun. C. 48.
fallax Broun. C. 48.
stenopus Broun. C. 880.
marginatus Sharp. C. 1000.
pallipes Broun. A. 6, xiv, 379.
labralis Broun. B. 1, iii, 151.
incertus Broun. B. 1, iii, 151.
Gaioxenus Broun, 1910.
pilipalpis Broun. B. 1, i, 8.
Taenarthrus Broun, 1914.
philpotti Broun. B. 1, ii, 85.
Zabronothus Broun, 1893.
striatulus Broun. C. 1327.
rufipes Broun. C. 1328.
oblongus Broun. B. 1, i, 8.
major Broun. T. xliv, 393.
aphelus Broun. T. xliv, 394.
Hypharpax MacLeay, 1825.
antarcticus Castelnau. C. 49.
abstrusus Bates. C. 49.
**australasiae* Dejean.
**australis* Dejean.
Syllectus Bates, 1878.
anomalus Bates. C. 52.

Subfamily HARPALINAE.

Harpalus Latreille, 1804.
novae-zealandiae Castelnau. *Trans. R. Soc. Vict.*, 1867, 108.
antarcticus Castelnau. *Trans. R. Soc. Vict.*, 1867, 107.
Allocinopus Broun, 1903.
sculpticollis Broun. A. 7, xi, 608.
ocularius Broun. A. 8, ii, 344.
smithi Broun. T. xliv, 391.
castaneus Broun. T. xliv, 392.
latitarsis Broun. T. xliii, 95.
angustulus Broun. T. xliv, 392.
Euthenarus Bates, 1874.
brevicollis Bates. C. 53.
puncticollis Bates. C. 53.
cilicollis Broun. T. xxxiv, 176.
huttoni Broun. T. xxxiv, 177.

Subfamily ZOLINAE.

Zolus Sharp, 1886.
helmsi Sharp. C. 1001.
atratus Broun. C. 1002.
femoralis Broun. A. 6, xiv, 311.
carinatus Broun. C. 754.
subopacus Broun. B. 1, iv, 277.
ocularius Broun. B. 1, v, 365.
labralis Broun. B. 1, vii, 599.
Megadromus Motschulsky, 1865.
viridilimbatus Motschulsky. *Bull. Mosc.*, iv, 251.
Synteratus Broun, 1909.
ovalis Broun. S. 85.

Subfamily POGONINAE.

Oöpterus Guérin, 1841.
laevicollis Bates. C. 54.
patulus Broun. C. 655.
fulvipes Broun. C. 936.
sobrinus Broun. C. 936.
collaris Broun. C. 1002.
pallidipes Broun. C. 1003.
puncticeps Broun. C. 1398.
clivinoides Guérin. *Voy. Pole Sud, Zool.*, iv, 43, and S. 86.
plicaticollis Blanchard. *Voy. Pole Sud, Zool.*, iv, 44, and S. 87.
latipennis Broun. A. 7, xi, 609.
probus Broun. A. 7, xi, 610.
parvulus Broun. A. 7, xi, 610.
pygmeatus Broun. A. 7, xix, 56.
nigritulus Broun. A. 8, ii, 342.
frontalis Broun. A. 8, ii, 342.
sculpturalis Broun. A. 8, ii, 343.
basalis Broun. B. 1, iv, 273.
minor Broun. B. 1, v, 364.
latifossus Broun. B. 1, v, 364.
suavis Broun. B. 1, v, 365.
laevigatus Broun. B. 1, vi, 389.
tripunctatus Broun. S. 87.
marrineri Broun. S. 88.
tarsalis Broun. S. 89.
elongellus Broun. S. 89.
Kenodactylus Broun, 1909.
capito Broun. S. 91.
Cyclothorax MacLeay, 1873.
rotundicollis White. C. 54.
insularis Motschulsky. C. 29.
Tarastethus Sharp, 1883.
puncticollis Sharp. C. 1004.
laeviventris Sharp. C. 1004.
alpinalis Broun. C. 1005.
debilis Sharp. C 1005.
cinctus Broun. C. 1005.
sulcicollis Bates. C. 28.
seriatoporus Bates. C. 28.
placens Broun. C. 28.
simplex Broun. A. 7, xi, 457.

Group GEODEPHAGA—*continued.*

Tarastethus—continued.
laevicollis Broun. A. 7, xi, 458.
pretiosus Broun. B. 1, i, 6.
strenuus Broun. A. 6, xiv, 308.
dubius Broun. A. 6, xiv, 309.
simulaus Broun. A. 6, xiv, 309.
southlandicus Broun. A. 8, ii, 350.
carbonarius Broun. A. 8, ii, 351.
amplipennis Broun. T. xliv, 386.
phyllocharis Broun. T. xliv, 387.
lewisi Broun. T. xliv, 388.
cordipennis Broun. T. xliv, 388.
convexux Broun. B. 1, v, 366.
diversus Broun. B. 1, v, 366.
halli Broun. B. 1, v, 367.
fovealis Broun. B. 1, v, 367.
longulus Broun. B. 1, v, 368.
propinquus Broun. B. 1, v, 369.
optatus Broun. B. 1, v, 369.
robustus Broun. B. 1, vii, 600.
eplicatus Broun. B. 1, viii, 675.
fuscipes Broun. B. 1, viii, 675.
insularis Broun. B. 1, viii, 676.
Sympiestus Sharp, 1866.
syntheticus Sharp. C. 1006.
fallax Broun. C. 1007.
oculator Broun. C. 1398.
modestus Broun. A. 6, xiv, 311.
frontalis Broun. B. 1, v, 370.

Subfamily BEMBIDIINAE.

Bembidium Latreille, 1804.
charile Bates. C. 55.
maorinum Bates. C. 55.
tairuense Bates. C. 55.
rotundicolle Bates. C. 56.
parviceps Bates. C. 56.
anchonoderum Bates. C. 57.
eustictum Bates. C. 57.
callipeplum Bates. C. 57.
orbiferum Bates. C. 58.
chalceipes Bates. C. 58.
hokitikense Bates. C. 59.
musae Broun. C. 755.
latiusculum Broun. C. 755.
nesophilum Broun. C. 828.
tantillum Broun. C. 828.
tekapoense Broun. C. 880.
attenuatum Broun. C. 881.
clevedonense Broun. C. 1007.
diaphanum Broun. C. 1007.
dehiscens Broun. C. 1009.
antipodum Broun. C. 1009.
tersatum Broun. C. 1010.
actuarium Broun. A. 7, xi, 611.
waikatoense Broun. B. 1, i, 9.
tinctellum Broun. B. 1, i, 9.
Cillenum Samouelle, 1819.
albescens Bates. C. 59.
chalmeri Broun. C. 881.
subcaecum Sharp. C. 1010.
alacris Broun. B. 1, vii, 601.
Tachys Shaum, 1860.
antarcticus Bates. C. 60.
latipennis Sharp. C. 1011.

Tachys—continued.
oreobius Broun. C. 1399.
cavelli Broun. C. 1400.
coriaceus Broun. A. 8, ii, 421.
Anillus Duval, 1851.
pallidus Broun. C. 918.
phyllobius Broun. A. 6, xii, 164.
monticola Broun. B. 1, i, 10.
marginatus Broun. B. 1, iii, 152.
pinctigerus Broun. B. 1, iii, 153.

Subfamily LEBIINAE.

Actenonyx White, 1846.
bembidioides White. C. 61.
Lebia Latreille, 1804.
bembidioides Fairmaire. *Rev. Zool.*. 1849, 32.
posticalis Guérin. *Voy. Coquille, Coleop.*, 58.
Wakefieldia Broun, 1880.
vittata Broun. C. 62.
Agonochila Chaudoir, 1848.
**binotata* White. C. 63.
Demetrida White, 1846.
lineella White. C. 64.
nasuta White. C. 64.
picea Chaudoir. C. 65.
ater Broun. C. 66.
moesta Sharp. C. 66.
lateralis Broun. B. 1, i, 10.
sinuata Broun. B. 1, v, 370.
Pedalopia Castelnau, 1867.
novae-zealandiae Castelnau. C. 67.

Subfamily PERICALINAE.

Scopodes Erichson, 1842.
fossulatus Blanchard. C. 68.
elaphroides White. C. 68.
edwardsi Bates. C. 68.
versicolor Bates. C. 68.
prasinus Bates. C. 69.
multipunctatus Bates. C. 69.
laevigatus Bates. C. 70.
venustus Broun. C. 756.
planus Broun. C. 756.
tardus Broun. C. 757.
pustulatus Broun. C. 757.
laevistriatus Broun. C. 829.
bryophilus Broun. C. 882.
cognatus Broun. C. 882.
antennalis Broun. C. 882.
nigrinus Sharp. C. 1011.
basalis Broun. C. 1012.
speciosus Broun. C. 1012.
viridis Broun. A. 7, xi, 612.
nigripes Broun. B. 1, i, 11.
instabilis Broun. B. 1, v, 371.

Family RHYSODIDAE.

Rhysodes Dalman, 1823.
aterrimus Broun. C. 214.
eminens Broun. C. 215.
orbitosus Broun. C. 215.
proprius Broun. C. 216.
pensus Broun. C. 215.

Group HYDRADEPHAGA.

Family DYTISCIDAE.

Homoeodytes Sharp, 1882.
hookeri White. C. 75.
scutellaris Sharp. C. 1331.
Rhantus Sharp, 1882.
pulverosus Stephens = *C. rufimanus* White. C. 74; C. 1333.
plantaris Sharp. C. 1333.
Lancetes Sharp, 1882.
lanceolatus Clark. C. 1335.

Family HYDROPORIDAE.

Antiporus Sharp, 1882.
uncifer Sharp. C. 1330.
wakefieldi Sharp. C. 71.
duplex Sharp. C. 72.
Antiporus—continued.
strigosulus Broun. C. 72.
nitidicornis Broun. C. 73.
Bidessus Sharp, 1882.
impressus Sharp. C. 1329.
plicatus Sharp. C. 1329.
huttoni Sharp. C. 1329.
Huxelhydrus Sharp, 1882.
syntheticus Sharp. *Trans. Roy. Dub. Soc.*, 1882.
virgatus Broun. C. 1014.
Copelatus Erichson. Sharp, 1882.
sharpi Broun. C. 1014 and 939.

Family GYRINIDAE.

Gyrinus, Linnaeus, 1733.
huttoni Pascoe. C. 76.

Group PHILHYDRIDA.

Family HYDROPHILIDAE.

Philhydrus Solier, 1834.
tritus Broun. C. 78.
variolosus Broun. C. 79.
abditus Sharp. C. 1018.
Berosus Leach, 1817.
mergus Broun. C. 883.
Phelerosus Sharp, 1884.
pallidipennis Sharp. C. 1023.
Saphydrus Sharp, 1884.
oblongus Broun. C. 81.
suffusus Sharp. C. 1015.
obesus Sharp. C. 1016.
antennatus Sharp. C. 1016.
longulus Sharp. C. 1016.
monticola Broun. C. 1401.
consonus Broun. B. 1, vi, 478.
collaris, Broun. B. 1, vi, 478.
Rygmodus White, 1846.
modestus White. C. 80.
pedinoides White. C 80.
incertus Broun. C. 81.
optimus Broun. C. 82.
cyaneus Broun. C. 659.
puncticeps Broun. C. 757.
femoratus Sharp. C. 1016.
tibialis Broun. C. 1017.
ovalis Sharp. C. 1017.
limbatus Broun. C. 1335.
alienus Broun. C. 1401.
nigripennis Broun. A. 7, xi, 612.
Tormus Sharp, 1884.
helmsi Sharp. C. 1019.
nitidus Broun. C. 1402.
Tormissus Broun, 1893.
marginatus Broun. C. 1021.
magnulus Broun. C. 1021.
Thomosis Broun, 1904.
†*guanicola* Broun. A. 7, xiv, 274, and S. 100.
Hydrostygnus Sharp, 1884.
linsi Sharp. C. 1020.
pontalis Broun. C. 84.
minor Broun. C. 1020.
bifoveatus Broun. C. 1021.
Hydrobius.
**assimilis* Hope.
Exydrus Broun, 1886.
flavicornis Broun. C. 84 and C. 940.
gibbosus Broun. C. 84 and C. 940.
Stygnohydrus Broun, 1893.
nitidus Broun. C. 1336.
femoralis Broun. B. 1, i, 12.
posticalis Broun. B. 1, v, 371.
Gitocyloma Broun, 1915.
nigratus Broun. B. 1, iv, 278.
Cyloma Sharp, 1872.
lawsonus Sharp. C. 85.
thomsonus Sharp. C. 1022.
guttulatus Sharp. C. 1022.
stewarti Broun. A. 6, xiv, 379.
Namostygnus Broun, 1909.
rufipes Broun. S. 99.
Cylomissus Broun, 1903.
glabratus Broun. A. 7, xi, 613.
Cyclonotum Dejean, 1833.
**marginale* Sharp. C. 83.
Psephoboragus Broun, 1893.
signatus Broun. C. 1403.
lineatus Broun. C. 1404.
dispar Broun. B. 1, i, 13.
Zeadolopus Broun, 1903.
spinipes Broun. A. 7, xi, 614.
Adolopus Sharp, 1884.
helmsi Sharp. C. 1023.
badius Broun. C. 86.
altulus Broun. C. 86.
vicinus Broun. C. 939.
rugipennis Broun. C. 939.
montanus Broun. C. 1336.
convexus Broun. C. 1404.
australis Broun. A. 8, iii, 223.
tibialis Broun. A. 8, iii, 224.
Cercyodes Broun, 1893.
laevigatus Broun. C. 941.
Cercyon.
**flavipes* Fabricius.
Hydraenodes Broun, 1919.
spinipennis Broun. B. 1, vi, 479.
Paracymus.
**nitidiusculus* Broun.

† From Bounty Islands.

Group BRACHELYTRA.

Family STAPHYLINIDAE.

Subfamily Aleocharinae.

Falagria Mannerheim, 1830.
micans Broun. C. 96.
subopaca Broun. C. 1405.
Ocalea Erichson, 1837.
socialis Broun. C. 90.
crepera Broun. A. 6, xiv, 380.
Baeostethus Broun, 1909.
chiltoni Broun. S. 97.
Aleochara Gravenhorst, 1802.
puber Broun. C. 90.
semifusca Broun. A. 6, xiv, 386.
subaenea Fauvel. C. 91.
Protopristus Broun. 1909.
minutus Broun. A. 8, iii, 226.
Calodera Mannerheim, 1830.
flavescens Broun. C. 93.
optabilis Broun. C. 94.
aeraria Broun. C. 94.
thoracica Broun. C. 95.
fulgens Broun. C. 95.
algophila Broun. C. 941.
sericophora Broun. A. 6, xiv, 381.
wallacei Broun. T. xliv, 596.
granifer Broun. A. 6, xiv, 381.
diversa Broun. A. 6, xiv, 382.
fultoni Broun. T. xliv, 596.
vestita Broun. A. 6, xiv, 383.
tumidella Broun. A. 6, xiv, 383.
bituberculata Broun. A. 6, xiv, 384.
fungicola Broun. A. 6, xiv, 384.
rufipennis Broun. C. 92.
Tachyusa Erichson, 1837.
fuscicornis Broun. C. 92.
Homalota Mannerheim, 1825.
cornigera Broun. C. 91.
atriceps Broun. C. 91.
**sordida* Marsham.
Polylobus Solsky, 1851.
sternalis Broun. C. 88.
Aphytopus Sharp, 1886.
gracilis Sharp. C. 1025.
pictulus Broun. B. 1, ii, 87.
porosus Broun. T. xliv, 394.
granifer Broun. T. xliv, 395.
guinnessi Broun. T. xliv, 395.
Gyrophaena Mannerheim, 1830.
punctata Broun. C. 87.
nugax Broun. C. 88.
densicornis Broun. C. 89.
versicolor Broun. C. 89.
atriceps Broun. C. 89.
carinulata Broun. B. 1, ii, 86.
Encephalus Stephens, 1832.
latulus Broun. A. 6, xiv, 386.
Myrmecopora Saulcy, 1864.
funesta Broun. T. xliv, 397.
granulata Broun. T. xliv, 398.

Subfamily Digramminae.

Digrammus Fauvel, 1900.
miricollis Fauvel. *Rev. Ent. Fr.*, xix, 124.

Subfamily Tachyporinae.

Conurus Stephens, 1832.
largulus Broun. C. 97.
austerus Broun. C. 97.
subruber Broun. C. 98.
badius Broun. C. 98.
flavithorax Broun. C. 98.
acerbus Broun. C. 99.
atricapillus Broun. C. 99.
auricomus Broun. C. 100.
nubilus Broun. C. 100.
maculosus Broun. C. 100.
maorinus Broun. C. 1025.
brevicornis Broun. C. 1405.
niticollis Broun. C. 1406.
asperellus Broun. B. 1, ii, 87.
laetulus Broun. B. 1, ii, 88.
morosus Broun. B. 1, viii, 676.
antennalis Broun. B. 1, viii, 677.
seminudus Broun. B. 1, viii, 677.

Subfamily Staphylininae.

Quedius Stephens, 1832.
ruficornis Broun. C. 111.
aeneoceps Broun. C. 111.
enodis Broun. C. 111.
veteratorius Broun. C. 112.
vividus Broun. C. 112.
arctifrons Broun. C. 112.
fuscatus Broun. C. 1027.
antipodus Sharp. C. 1028.
edwardsi Sharp. C. 1029.
insolitus Sharp. C. 1029.
latifrons Sharp. C. 1030.
discrepans Broun. C. 1030.
latimanus Broun. C. 1031.
collinus Broun. C. 1031.
cavelli Broun. C. 1032.
agathis Broun. C. 1407.
sciticollis Broun. A. 6, xiv, 420.
conspicuellus Broun. A. 6, xiv, 421.
scutellaris Broun. A. 6, xiv, 422.
puncticollis Broun. A. 6, xiv, 422.
ambiguus Broun. A. 6, xiv, 423.
taieriensis Broun. A. 6, xiv, 424.
tinctellus Broun. B. 1, i, 14.
aeneiventris Broun. B. 1, i, 14.
longiceps Broun. B. 1, i, 15.
hilaris Broun. A. 8, iii, 226.
burrowsi Broun. B. 1, iv, 278.
hirtipennis Broun. B. 1, iv, 279.
hallianus Broun. B. 1, v, 372.
recticeps Broun. B. 1, v, 373.
megophthalmus Broun. B. 1, v, 373.
urbanus Broun. B. 1, vi, 480.
iridescens Broun. B. 1, vi, 480.
eruensis Broun. T. xliv, 398.
xenophaenus Broun. T. xliv, 399.
**fulgidus* Fabricius.
badius Broun. B. 1, viii, 678.
bryocharis Broun. B. 1, viii, 678.
maorinus Broun. B. 1, viii, 679.
ohiaensis Broun. B. 1, viii, 679.
slipsensis Broun. B. 1, viii, 680.

Group BRACHELYTRA—*continued.*

Cafioquedus Sharp, 1866.
  gularis Sharp. C. 1033.
Staphylinus Linnaeus, 1758.
  oculatus Fabricius. C. 107.
  huttoni Broun. C. 108.
Xantholinus Serville, 1825.
  sharpi Broun. C. 102.
  cultus Broun. C. 103.
  arecae Broun. C. 103.
  mediocris Broun. C. 104.
  labralis Broun. C. 104.
  socius Fauvel. C. 104.
  puncticeps Broun. C. 104.
  **punctulatus* Paykull.
Pachycorynus Motschulsky, 1858.
  dimorphus Fauvel. *Rev. Ent. Soc. Fr.*, 1892, 92.
Metoponcus Kraatz, 1857.
  brouni Sharp. C. 106.
  fulvipes Broun. C. 106.
  rufulus Broun. C. 106.
Cafius Leach, 1830.
  litoreus Broun. C. 108.
  maritimus Broun. C. 109.
  quadri-impressus (fem.), White. C. 105. No. 194 = *caviceps* (male) Broun. C. 942.
  algophilus Broun. A. 6, xiv, 419.
Othius Stephens, 1832.
  adustus Broun. C. 101.
  angustus Broun. C. 1026.
  puncticeps Broun. A. 6, xiv, 419.
Philonthus.
  **aeneus* Rossi.
  **scybalarius* Nordmann.
  **affinis* Roth.
  **nigritulus* Gravenhorst.

Subfamily PAEDERINAE.

Lithocharis Lacordaire, 1835.
  zealandicus Redtenbacher. C. 114.
  mandibularis Broun. C. 114.
  ventralis Broun. C. 115.
  caecus Broun. A. 6, xiv, 424.
  granipennis Broun. B. 1, i, 16
  longipennis Broun. T. xliv, 399.
Phanophilus Sharp, 1886.
  comptus Broun. C. 1026 and 114.
Hyperomma Fauvel, 1878.
  dispersum Fauvel. C. 1408.
  mandibulare Broun. C. 1409.
  duplicatum Broun. C. 1409.
  sanguineum Broun. A. 6, xiv, 425.
  tenellum Broun. A. 8, iii, 227.
  subcaecum Broun. B. 1, vi, 481.
  lobatum Broun. B. 1, vi, 481.
  picipenne Broun. B. 1, vi, 482.
  discrepans Broun. B. 1, vi, 483.
  flavipes Broun. B. 1, viii, 681.
Dimerus Fauvel.
  stilbus Broun. B. 1, i, 15.
  bisulciceps Broun. B. 1, v, 374.
  vicinus Broun. B. 1, vi, 483.
  whitehorni Broun. T. xliv, 400.

Subfamily OXYTELINAE.

Coprostygnus Sharp, 1886.
  sculptipennis Sharp. C. 1027.
  optandus Broun. C. 1409.
  curvipes Broun. B. 1, vi, 484.
  picipennis Broun. B. 1, vi, 485.
Holotrochus Erichson, 1840.
  ferrugineus Broun. C. 1034.
  brevipennis Broun. C. 1034.
  laevigatus Broun. B. 1, i, 16.
  caecus Broun. B. 1, i, 17.
  gracilis Broun. B. 1, i, 17.
  nitidorsis Broun. B. 1, i, 17.
  montanus Broun. B. 1, i, 18.
  setigerus Broun. T. xliv, 401.
Phloeoneus.
  cordicollis Broun. A. 7, xix, 57.
Bledius Leach.
  bideetifrons Broun. T. xliv, 401.
Oxytelus.
  **rugosus* Fabricius.

Subfamily OMALINAE.

Omalium Gravenhorst, 1802.
  hebes Broun. C. 116.
  sulcithorax Broun. C. 116.
  agrestis Broun. C. 117.
  spadix Broun. C. 117.
  pullum Broun. C. 120.
  tibiale Broun. C. 120.
  littoreum Broun. C. 942.
  sagoloide Sharp. C. 1035.
  actobium Broun. C. 1035.
  cariniferum Broun. C. 1036.
  antipodum Broun. C. 1036.
  chalmeri Broun. C. 1037.
  micrarthrum Broun. C. 1037.
  cognatum Broun. C. 1038.
  monilifer Broun. C. 1038.
  debile Broun. C. 1039.
  prolixum Broun. C. 1039.
  stenosoma Broun. C. 1040.
  tenellum Broun. C. 1410.
  fuscicentre Broun. A. 6, xiv, 426.
  australe Broun. A. 6, xiv, 426.
  philpotti Broun. A. 6, xiv, 427.
  perplexum Broun. A. 6, xiv, 428.
  nemobium Broun. B. 1, i, 18.
  laetipenne Broun. B. 1, i. 19.
  longiceps Broun. B. 1, ii, 89.
  hilarum Broun. B. 1, ii, 90.
  sanguineum Broun. B. 1, ii, 90.
  planimarginatum Broun. A. 8, iii, 229.
  setipes Broun. A. 8, iii, 230.
  robustum Broun. T. xliii, 96.
  fossigerum Eppelsheim. T. xliii, 93.
  venator Broun. S. 98.
  flavipalpi Broun. A. 8, iii, 228.
Eupsorus Broun, 1904.
  costatus Broun. A. 7, xiv, 46.
Ischnoderus Fauvel, 1867.
  tectus Broun. C. 117.
  genalis Broun. C. 118.

Group BRACHELYTRA—*continued.*

Ischnoderus—continued.
pictulus Broun. C. 1040.
morosus Broun. C. 1041.
fultoni Broun. C. 1041.
politulus Broun. C. 119.
cognatus Broun. B. 1, i, 20.
arecobius Broun. B. 1, i, 20.
curtipennis Broun. B. 1, iv, 280.
Omalissus Broun, 1893.
castaneus Broun. C. 1042.
Omalissus—continued.
scutosus Broun. B. 1, iv, 281.
Trogophlaeus Mannerheim, 1830.
zealandicus Sharp. *Ent. Mag.*, xxxvi, 233.
maritimus Broun. A. 7, xi, 615.
Blediotrogus Sharp, 1900.
guttiger Sharp. *Ent. Mag.*, xxxvi, 234.
cribricollis Fauvel. *Rev. Ent. Fr.*, xix, 184.

Group CLAVICORNES.

Family CLAMBIDAE.

Clambus Fisher, 1820.
domesticus Broun. C. 762.
vestitus Broun. C. 762.
suffusus Broun. C. 762.

Family SILPHIDAE.

Necrophilus Latreille, 1829.
prolongatus Sharp. C. 760.
Camiarus Sharp, 1876.
thoracicus Sharp. C. 148.
indiscretus Broun. C. 149.
convexus Sharp. C. 150.
estriatus Broun. T. xliv, 415.
Zenocolon Broun, 1917.
laevicollis Broun. B. 1, v, 387.
Inocatops Broun, 1893.
compactus Broun. C. 1066.
flectipes Broun. C. 1067.
nigrescens Broun. C. 1339.
concinnus Broun. C. 150.
spinifer Broun. B. 1, v, 383.
granipennis Broun. B. 1, v, 384.
elongellus Broun. B. 1, v, 384.
separatus Broun. B. 1, v, 385.
impressus Broun. B. 1, vi, 520.
Microsilpha Broun, 1886.
littorea Broun. C. 895.
Asphaerites Broun, 1893.
nitidus Broun. C. 1068.
Catopsolius Sharp, 1886.
laevicollis Sharp. C. 1069.
Isocolon Broun, 1893.
hilaris Broun. C. 1070.
frontale Broun. B. 1, vi, 521.
modestum Broun. B. 1, vi, 521.
oruruensis Broun. B. 1, viii, 683.
Choleva Latreille, 1796.
antennalis Broun. C. 152.
alacris Broun. C. 152.
granifer Broun. C. 890.
fulvitarsis Broun. C. 946.
lugubris Sharp. C. 1069.
relata Broun. C. 1339.
phyllobia Broun. C. 1433.
monticola Broun. C. 1434.
hunuensis Broun. C. 1434.
marginalis Broun. A. 6, xv, 87.
suturalis Broun. A. 6, xv, 88.
Choleva—continued.
nemoralis Broun. A. 8, iii, 230.
caeca Broun. T. xliv, 414.
castanea Broun. T. xliv, 415.
brunneipes Broun. T. xliii, 97.
avivorus Broun. S. 101.
crenatella Broun. B. 1, vii, 609.
flectipes Broun. B. 1, vii, 609.
curvigera Broun. B. 1, vii, 610.
Zeagyrtes Broun, 1917.
vitticollis Broun. B. 1, v, 386.
Allocatops Broun, 1893.
ovalis Broun. C. 1435.
Mesocolon Broun, 1880.
clathrata Broun. C. 153.
liturata Broun. C. 154.
puncticeps Broun. C. 154.
undulata Broun. C. 154.
bicolor Broun. C. 155.
nebulosa Broun. C. 155.
maculifer Broun. C. 156.
hirtalis Broun. C. 156.
punctulata Broun. C. 157.
torva Broun. C. 157.
domestica Broun. C. 158.
varia Broun. C. 946.
strigicollis Broun. B. 1, vii, 610.
nitidulus Broun. B. 1, vii, 611.
labralis Broun. B. 1, vii, 611.
Baeosilpha Broun, 1895.
rufescens Broun. A. 6, xv, 85.
Mesagyrtes Broun, 1895.
scabripes Broun. A. 6, xv, 86.
Silphotelus Broun, 1895.
nitidus Broun. A. 6, xv, 84.
obliquus Broun. T. xliv, 416.

Family SCYDMAENIDAE.

Scydmaenus Latreille, 1802.
edwardsi Sharp. C. 144.
ambiguus Broun. C. 145.
puncticollis Broun. C. 146
princeps Broun. C. 924.
galerus Broun. C. 924.
elongellus Broun. C. 1338.
laetans Broun. C. 663.
cilipes Broun. A. 6, xii, 178.
cedius Broun. A. 6, xii, 179.
allocerus Broun. A. 6, xii, 179.

Group CLAVICORNES—*continued.*

Scydmaenus—continued.
brachycerus Broun. A. 6, xii, 180.
xanthopus Broun. A. 6, xii, 181.
heterarthus Broun. A. 6, xii, 181.
relatus Broun. A. 6, xii, 182.
insignis Broun. A. 6, xii, 182.
angulifrons Broun. B. 1, iv, 307.
sulciferus Broun. B. 1, iv, 308.
latuliceps Broun. B. 1, iv, 309.
fragilis Broun. B. 1, iv, 309.
Adrastia Broun, 1881.
laetans Broun. C. 663.
clavatella Broun. B. 1, iv, 310.
Phaganophana King, 1864.
setosa Sharp. C. 146.
picicollis Broun. C. 147.
calva Broun. C. 147.
oreas Broun. C. 925.
lanosa Broun. C. 925.
angustata Broun. C. 926.
planiceps Broun. C. 1063.
munroi Broun. C. 1063.
antennalis Broun. C. 1064.
stenocera Broun. C. 1064.
latiuscula Broun. C. 1064.
sanguinea Broun. C. 1065.
erythronota Broun. C. 1065.
ovipennis Broun. C. 1339.
russata Broun. C. 1432.
monilifer Broun. C. 1432.
angulata Broun. C. 1433.
alacer Broun. B. 1, iv, 310.
halli Broun. B. 1, iv, 311.
palpalis Broun. B. 1, iv, 312.
sinuata Broun. B. 1, iv, 313.
Sciacharis Broun, 1893.
fulva Broun. C. 1062.

Family PSELAPHIDAE.

Plesiotyrus Broun, 1914.
crassipes Broun. C. 1337.
Euglyptus Broun, 1893.
elegans Broun. C. 1412.
costifer Broun. A. 6, xii, 166.
foveicollis Broun. T. xliv, 403.
longicornis Broun. T. xliv, 404.
sublaevis Broun. B. 1, vii, 603.
longiceps Broun. B. 1, vii, 604.
abnormis Broun. B. 1, vii, 604.
Microtyrus Broun, 1893.
punctatus Broun. C. 1413.
Phormiobius Broun, 1917.
halli Broun. B. 1, v, 382.
Agatyrus Broun, 1917.
fulvihirtus Broun. B. 1, v, 383.
Tyrogetus Broun, 1893.
optandus Broun. A. 6, xii, 166.
palpalis Broun. B. 1, i, 23.
Hamotulus Schaufuss, 1887.
mutandus Sharp. C. 121.
armatus Broun. C. 1043.
spinipes Broun. C. 1411.
sternalis Broun. A. 6, xii, 168.
curvipes Broun. A. 6, xii, 170.

Hamotulus—continued.
frontalis Broun. B. 1, ii, 94.
angulipes Broun. B. 1, iii, 171.
robustus Broun. B. 1, iv, 305.
fuscipalpis Broun. B. 1, iv, 306.
cornutus Broun. B. 1, iv, 307.
Pselaphus Herbst, 1792.
pauper Sharp. C. 122.
pilistriatus Broun. C. 123.
dulcis Broun. C. 660.
caecus Broun. C. 943.
delicatus Broun. C. 943.
fuscopilus Broun. C. 944.
citimus Broun. C. 1043.
meliusculus Broun. C. 1044.
carelli Broun. C. 1414.
sulcicollis Broun. C. 1415.
pilifrons Broun. B. 1, ii, 93.
trifoveatus Broun. B. 1, iii, 172.
urquharti Broun. B. 1, v. 379.
oviceps Broun. B. 1, v. 380.
caridorsis Broun. B. 1, viii, 681.
Gastrobothrus Broun, 1886 = *Physa* Raffray, 1890 (not of Draparnaud, 1801).
inflata Sharp. C. 124.
sharpi Broun. C. 124.
abdominalis Broun. C. 125 and 758.
Eupines King, 1864.
rudicornis Broun. C. 759.
micans Sharp. C. 126.
clavata Broun. C. 126.
picipes Broun. C. 127.
dispar Sharp. C. 127.
impressifrons Broun. C. 128.
munda Broun. C. 129.
crassicornis Broun. C. 129.
deformis Sharp. C. 130.
impar Sharp. C. 130.
grata Sharp. C. 131
altula Broun. C. 131.
nasuta Broun. C. 132.
sanguinea Broun. C. 132.
pagana Broun. C. 660.
ignota Broun. C. 661.
glabrata Broun. C. 830.
nemoralis Broun. C. 831.
punctata Broun. C. 831.
calcarata Broun. C. 831.
sylvicola Broun. C. 919.
fraudulenta Broun. C. 944.
euplectoides Broun. C. 1045.
decens Broun. C. 1046.
munroi Broun. C. 1046.
forficulida Broun. C. 1047.
foveatissima Broun. C. 1047.
platynota Broun. C. 1338.
conspicua Broun. C. 1415.
costata Broun. C. 1416.
platyarthra Broun. C. 1417.
mundula Broun. C. 1417.
fulvitarsis Broun. C. 1418.
sternalis Broun. A. 6, xii, 171.
allocera Broun. A. 6, xii, 172.
setifer Broun. A. 6, xii, 173.
diversa Broun. A. 6, xii, 174.

Group CLAVICORNES—*continued.*

Eupines—continued.
lewisi Broun. B. 1, i, 24.
simplex, Broun. A. 8, xi, 206.
nesobia Broun. B. 1, ii, 92.
clemens, Broun. B. 1, vii, 607.
Parmipalpus Broun, 1881.
montivagus Broun. C. 662.
Startes Broun, 1886.
sculpturata Broun. C. 830.
foveata Broun. A. 6, xii, 170.
Dalma Sharp, 1874.
pubescens Sharp. C. 133.
gigantea Broun. B. 1, iii, 164.
graniceps Broun. B. 1, vii, 605.
Dalmisus Sharp, 1886.
batrisodes Sharp. C. 1049.
Sagola Sharp, 1874.
major Sharp. C. 135.
prisca Sharp. C. 136.
misella Sharp. C. 136.
parva Sharp. C. 136.
pulcher Broun. C. 137.
notabilis Broun. C. 137.
deformipes Broun. C. 138.
denticollis Broun. C. 138.
genalis Broun. C. 663.
terricola Broun. C. 832.
castanea Broun. C. 884.
excavata Broun. C. 884.
sulcator Broun. C. 885.
osculans Broun. C. 885.
fovealis Broun. C. 886.
elevata Broun. C. 886.
brevitarsis Broun. C. 887.
bipunctata Broun. C. 887.
duplicata Broun. C. 888.
tenuis Broun. C. 888.
convexa Broun. C. 889.
insignis Broun. C. 1049.
hirtalis Broun. C. 1050.
sobrina Broun. C. 1050.
rectipes Broun. C. 1051.
insolens Broun. C. 1051.
punctata Broun. C. 1052.
fulva Broun. C. 1052.
ruficeps Broun. C. 1053.
parallela Broun. C. 1053.
anisarthra Broun. C. 1053.
macronyx Broun. C. 1418.
mimica Broun. C. 1419.
robusta Broun. C. 1420.
laminata Broun. C. 1421.
immota Broun. C. 1422.
flavipes Broun. C. 1422.
elongata Broun. C. 1423.
lineata Broun. A. 6, xii, 175.
pertinax Broun. A. 6, xii, 176.
citima Broun. A. 6, xii, 177.
rugifrons Broun. A. 6, xv, 73.
spinifer Broun. A. 6, xv, 75.
eminens Broun. A. 6, xv, 75.
punctulata Raffray. *Rev. Ent. Fr.*, 1893, 22.
frontalis Raffray. *Rev. Ent. Fr.*, 1893, 23.
Sagola—continued.
sharpi Raffray. *Rev. Ent. Fr.*, 1893, 26.
brevicornis Raffray. *Rev. Ent. Fr.*, 1893, 27.
carinata Broun. A. 8, x, 622.
ventralis Broun. A. 8, x, 623.
occipitalis Broun. A. 8, x, 624.
longula Broun. A. 8, x, 625.
pallidula Broun. A. 8, x, 626.
spiniventris Broun. A. 8, x, 627.
grata Broun. A. 8, x, 628.
bifoveiceps Broun. A. 8, x, 629.
biimpressa Broun. A. 8, x, 630.
clavatella Broun. A. 8, x, 631.
lawsoni Broun. A. 8, x, 632.
latula Broun. A. 8, x, 633.
puncticeps Broun. A. 8, viii, 489.
laticeps Broun. A. 8, viii, 490.
angulifer Broun. A. 8, viii, 491.
nitida Broun. A. 8, viii, 492.
cognata Broun. A. 8, viii, 494.
diversa Broun. A. 8, viii, 495.
latistriata Broun. A. 8, viii, 495.
basalis Broun. A. 8, viii, 496.
longicollis Broun. A. 8, viii, 498.
puncticollis Broun A. 8, viii, 499.
auripila Broun. A. 8, viii, 500.
guinnessi Broun. A. 8, viii, 502.
longipennis Broun. A. 8, viii, 504.
electa Broun. B. 1, ii, 91.
halli Broun. B. 1, iii, 155.
colorata Broun. B. 1, iii, 156.
dilucida Broun. B. 1, iii, 157.
insueta Broun. B. 1, iii, 157.
suturalis Broun. B. 1, iii, 158.
fuscipalpis Broun. B. 1, iii, 159.
disparata Broun. B. 1, iii, 160.
bituberata Broun. B. 1, iii, 160.
socia Broun. B. 1, iv, 281.
setiventris Broun. B. 1, iv, 282.
crassulipes Broun. B. 1, iv, 283.
opercularis Broun. B. 1, iv, 284.
brevisternis Broun. B. 1, iv, 284.
rustica Broun. B. 1, iv, 285.
confusa Broun. B. 1, iv, 286.
longipes Broun. B. 1, iv, 287.
indiscreta Broun. B. 1, iv, 288.
rotundiceps Broun. B. 1, iv, 289.
fulvipennis Broun. B. 1, iv, 289.
bifida Broun. B. 1, iv, 290.
posticalis Broun. B. 1, iv, 291.
laetula Broun. B. 1, iv, 291.
concolorata Broun. B. 1, iv, 292.
unicalis Broun. B. 1, v, 376.
dickensis Broun. B. 1, v, 377.
robustula Broun. B. 1, v, 378.
hectorii Broun. B. 1, v, 378.
monticola, Broun. T. xliv, 402.
bilobata Broun. B. 1, vi, 486.
tenebrica Broun. B. 1, vi, 487.
subcuneata Broun. B. 1, vi, 488.
strialis Broun. B. 1, vi, 489.
rectipennis Broun. B. 1, vi, 489
valida Broun. B. 1, vi, 490.
cilipes Broun. B. 1, vi, 491.

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foveiventris Broun. B. 1, vi, 492.
striatifrons Broun. B. 1, vi, 492.
cordiceps Broun. B. 1, vi, 493.
fagicola Broun. B. 1, vi, 494.
ignota Broun. B. 1, vi, 495.
furcata Broun. B. 1, vi, 495.
aemula Broun. B. 1, vi, 496.
fasciculata Broun. B. 1, vi, 497.
minuscula Broun. B. 1, vi, 497.
acuminata Broun. B. 1, vi, 498.
rufescens Broun. B. 1, vi, 499.
bipuncticeps Broun. B. 1, vi, 499.
affinis Broun. B. 1, vi, 500.
planipennis Broun. B. 1, vi, 500.
brevifossa Broun. B. 1, vi, 501.
arboricola Broun. B. 1, vi, 502.
remixta Broun. B. 1, vi, 502.
planicula Broun. B. 1, vi, 503.
lineiceps Broun. B. 1, vi, 504.
dissonans, Broun B. 1, vii, 601.
distorta Broun. B. 1, vii, 602.
Stenosagola Broun, 1919.
gracilis Broun. C. 1424.
crassicornis Broun. A. 8, viii, 501.
connata Broun. A. 8, viii, 503.
planiocula Broun. B. 1, vi, 505.
oblongiceps Broun. B. 1, vi, 505.
griseipila Broun. B. 1, vi, 506.
Exeirarthra Broun, 1893.
enigma Broun. C. 1054.
pallida Broun. C. 1424.
angustula Broun. B. 1, v, 374.
longiceps Broun. B. 1, v, 375.
parviceps Broun. B. 1, vi, 486.
Vidamus Raffray, 1898.
convexus Sharp. C. 139.
modestus Broun. A. 8, xi, 203.
sternalis Broun. A. 8, xi, 204.
trochanteralis Broun. A. 8, viii, 691.
armiferus Broun. A. 8, viii, 692.
congruus Broun. B. 1, iv, 301.
bryophilus Broun. B. 1, iii, 166.
clavipes Broun. B. 1, iv, 302.
punctulatus Broun. B. 1, iv, 302.
gracilipes Broun. B. 1, v, 379.
simplex Broun. B, 1, vi, 511.
ovicollis Broun. B. 1, vi, 511.
muscicola Broun. B. 1, vi, 512.
nitidus Broun. B. 1, vi, 513.
fossalis Broun. B. 1, vi, 513.
calcaratus Broun. T. xliv, 411.
incertus Reitter. T. xliv, 411.
Vidamodes Broun, 1919.
furvus Broun. B. 1, vii, 606.
Sagolonus Raffray, 1898.
patronus Broun. C. 1060.
impressus Broun. B. 1, i, 21.
Gabata Raffray.
bifoveata Broun. B. 1, vi, 514.
parallela Broun. B. 1, vi, 515.
spinipes Broun. B. 1, i, 21.
Zelandius Raffray, 1898.
asper Broun. C. 140.
usitatus Broun. B. 1, i, 22.

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fovealis Broun. A. 8, xi, 205.
raffrayi Broun. A. 8, viii, 693.
illustris Broun. A. 8, viii, 695.
fulgens Broun. A. 8, viii, 696.
basalis Broun. B. 1, iii, 167.
spinifer Broun. B. 1, iii, 167.
brookesi Broun. B. 1, iv, 303.
tuberalis Broun. B. 1, iv, 304.
Whitea Hutton, 1894 = *Brounia*, Raffray 1898 (not of Sharp, 1878).
laevifrons Broun. C. 1425.
Plectomorphus Raffray, 1898.
spinifer Broun. C. 1426.
longiceps Broun. A. 8, xi, 200.
brevicornis Broun. A. 8, xi, 201.
egenus Broun. A. 8, xi, 202.
laminifer Broun. B. 1, iv, 300.
sciliventris Broun. B. 1, vi, 507.
anguliferus Broun. B. 1. vi, 508.
rugiceps Broun. B. 1, vi, 509.
insignis Broun. B. 1, vi. 509.
collinus Broun. B. 1, vi, 510.
optandus Broun. T. xliv, 412.
longipes Broun. T. xliv, 412.
Euplectus Leach, 1817.
trisulcicollis Broun. C. 140.
longulus Broun. C. 141.
opacus Sharp. C. 141.
sculpturatus Broun. C. 142.
frontalis Broun. C. 142.
brevitarsis Broun. C. 143.
ovicollis Broun. C. 143.
foveolatus Broun. C. 143.
tuberigerus Broun. C. 760.
crassipes Broun. C. 919
patruelis Broun. C. 919.
monticola Broun. C. 920.
ovithorax Broun. C. 920.
obnisus Broun. C. 921.
vacuus Broun. C. 921.
incomptus Broun. C. 921.
mirificus Broun. C. 922.
u-impressus Broun. C. 923.
careus Broun. C. 923.
eminens Broun. C. 945.
auripilus Broun. C. 945.
moerens Broun. C. 1055.
lepiphorus Broun. C. 1056.
validus Broun. C. 1056.
scruposus Broun. C. 1057.
allocephalus Broun. C. 1057.
acuminatus Broun. C. 1058.
clevedonensis Broun. C. 1058.
sandageri Broun. C. 1059.
personatus Broun. C. 1059.
unicus Broun. C. 1060.
verticalis Broun. C. 1061.
antiquus, Broun. C. 1061.
munroi Broun. C 1426.
obscurus Broun. C. 1427.
coxalis Broun. C. 1428.
inscitus Broun. C. 1428.
iracundus Broun. C. 1429.
caudatus Broun. C. 1429.

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parvulus Broun. A. 6, xv, 77.
modestus Broun. A. 6, xv, 78.
arohaensis Broun. A. 6, xv. 79.
foveiceps Broun. A. 6, xv, 80.
semiopacus Broun. A. 6, xv, 81.
pusillus Broun. A. 6, xv, 82.
caviceps Broun. A. 7, xiv, 48.
sulciceps Broun. A. 7, xiv, 49.
Pycnoplectus Reitter.
cephalotes Reitter. T. xliv, 410.
Byraxis Reitter.
illustris Broun. B. 1, iii, 168.
anisarthra Broun. B. 1, iii, 169.
bisulsifrons Broun. B. 1, iii, 170.
lewisi Broun. B. 1, iii, 170.
monstrosa Reitter. T. xliv, 413.
rhyssarthra Broun. T. xliv, 413.
halli Broun. B. 1, vii, 608.
acceptus Broun. B. 1, viii, 683.
Alloplectus Broun, 1911.
claviger Broun. C. 1480.
picipennis Broun. A. 8, viii, 698.
subcaecus Broun. A. 8, viii, 699.
Kenocoelus Broun. 1911.
dimorphus Broun. A. 8, viii, 701.
Eleusomatus Raffray.
ovicollis Broun. B. 1, iv, 305.
vidamoides Broun. B. 1, vi, 516.
oculatus Broun. B. 1, vi, 516.
subcaecus Broun. B. 1, vi, 516.
Placodium.
zenarthrum Broun.
Patreus Broun, 1904.
lewisi Broun. A. 7, xiv, 47.
Euplectopsis Raffray.
sanguineus Broun. A. 8, xi, 196.
duplicatus Broun. A. 8, xi, 197.
clavatulus Broun. A. 8, xi, 199.
granulatus Broun. A. 8, viii, 686.
fastigiatus Broun. A. 8. viii, 687.
eruensis Broun. B. 1, iv, 294, and T. xliv, 408.
mucronellus Broun. A. 8, viii, 689.
tumidus Broun. A. 8, viii, 690.
tibialis Broun. B. 1, iii, 161.
terrestris Broun. B. 1, iii, 162.
femoralis Broun. B. 1, iii, 163.
curvipennis Broun. B. 1, iii, 164.
perpunctatus Broun. B. 1, iv, 293.
nitipennis Broun. B. 1, iv, 294.
duplex Broun. B. 1, iv, 295.
cuneiceps Broun. B. 1, iv, 296.
bryocharis Broun. B. 1, iv, 296.
blandiatus Broun. B. 1, iv, 297.
impressus Broun. B. 1, iv, 298.
dorsalis Broun. B. 1, iv, 299.
elongellus Broun. B. 1, iv, 299.
crassulus Broun. B. 1, vi, 506.
longicollis Reitter, T. xliv, 405.
macrocephalus Reitter. T. xliv, 405.
brevicollis Reitter. T. xliv, 405.
rotundicollis Reitter. T. xliv, 405.

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trichonyformis Reitter. T. xliv, 406.
schizocnemis Broun. T. xliv, 406.
carinatus Broun. T. xliv, 407.
antennalis Broun. T. xliv, 407.
heterarthrus Broun. T. xliv, 409.
biimpressus Broun. T. xliv, 410.
Eupinogitus Broun, 1919.
sulcipennis Broun. B. 1, vi, 518.
Neosampa Broun, 1919.
granulata Broun. B. 1, vi, 519.
Anabaxis Raffray.
minor Broun. B. 1, vi, 519.

Family TRICHOPTERYGIDAE.

Trichopteryx Kirby, 1826.
inconspicua Matthews. C. 1436.
Ptenidium Erichson, 1845.
lawsoni Matthews. C. 1437.
posticale Broun. C. 1437.
proprium Broun. C. 1438.
carelli Broun. C. 1438.
Actidium Matthews, 1868.
lineare Matthews. C. 1439.
Actinopteryx Matthews, 1872.
australis Matthews. C. 1440.
Ptinella Motschoulski, 1844.
fauvelli Matthews. *Mon. Trichop. Suppl.*, 19.

Family CORYLOPHIDAE.

Anisomeristes Matthews, 1886.
sharpi Matthews. *Ent. Mon. Mag.*, 1886, xxii, 425.
ater Matthews. *Ent. Mon. Mag.*, 1886, xxii, 425.
Sacina Broun, 1893.
oblonga Broun. C. 1071.
laetans Broun. B. 1, ii, 101.
curtula Broun. B. 1, iii, 173.
Sericoderus Stephens, 1829.
fulvicollis Broun. C. 1072.
scutellaris Broun. C. 1073.
basalis Broun. C. 1073.

Family COCCINELLIDAE.

Coccinella Linnaeus, 1735.
tasmanii White. C. 645.
coriacea Broun. C. 1319.
novae-zealandiae Colenso. T. xx, 4.
**11-punctata* Linnaeus.
**californica* Mannerheim.
**sanguinea* Linnaeus.
Leis Mulsant, 1851.
antipodum Mulsant. C. 645.
**conformis* Boisduval.
Rhizobius.
**ventralis* Erichson.
Cranophorus Mulsant, 1851.
venustus Pascoe. C. 650.
Orcus.
**chalybeus* Boisduval.
**australasiae* Boisduval.

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Scymnus Kugelann, 1794.
eximius Broun. C. 646.
flavihirtus Broun. C. 646.
acceptus Broun. C. 647.
macrostictus Broun. T. xliii, 114.
consors Broun. C. 647.
tristis Broun. C. 647.
pallidiceps Broun. C. 648.
fagus Broun. C. 648.
terrenus Broun. C. 648.
rarus Broun. C. 649.
suffusus Broun. C. 649.
minutulus Broun. C. 649.
picinus Broun. C. 649.
sedatus Broun. C. 813.
villosus Broun. C. 814.
circularis Sharp. *Insect Life*, 1889, 365.
prolongatus Broun. B. 1, iii, 264.
halli Broun. B. 1, iii, 265.
circularis Sharp. B. 1, iii, 265.
nigritulus Broun. B. 1, iii, 265.
Novius.
**cardinalis* Mulsart.
Hippodamia.
**convergens* Guérin.
Holopsis Broun, 1886.
nigellus Broun. C. 814.
pallidus Broun. C. 815.
lawsoni Broun. C. 815.
pictulus Broun. C. 1503.
rotundatus Broun. C. 1503.
Cryptolaemus.
**montrouzeri* Mulsart.
Veronicobius Broun, 1893.
hirtus Broun. C. 1393.

Family EROTYLIDAE.

Cryptodacne Sharp, 1878.
synthetica Sharp. C. 641.
lenis Broun. C. 641.
vagepunctata Broun. C. 813.
vittata Broun. C. 873.
pubescens Broun. C. 1319.
ferrugata Broun. B. 1, i, 78.
ocularia Broun. T. xlv, 163.
Triplax Paykull, 1798.
brouni Pascoe. C. 642.
Thallis Erichson, 1842.
polita White. C. 643.
Tritomidea.
rubripes Reitter. B. 1, i, 78.

Family COLYDIIDAE.

Subfamily Colydiinae.

Tarphiomimus Wollaston, 1873.
indentatus Wollaston. C. 182.
wollastoni Sharp. C. 1080.
tuberculatus Broun. T. xliv, 417.
Dryptops Broun, 1886.
dorsalis Broun. C. 763.
undosus Broun. C. 764.
acuminatus Broun. C. 183.
Ulonotus Erichson, 1845.
antarcticus White. C. 187.
discedens Sharp. C. 187.
brouni Sharp. C. 188.
viridipictus Wollaston. C. 188.
asper Sharp. C. 189.
integer Sharp. C. 189.
lawsoni Wollaston. C. 189.
aberrans Broun. C. 189.
atratus Broun. C. 190
punctatus Broun C. 894.
isostictus Broun. C. 926.
carus Broun. C. 947.
fuscatus Broun. C. 948.
rufescens Broun. C. 948.
cinereus Broun. C. 948.
integratus Broun. C. 949.
fulvus Broun. C. 1080.
dissimilis Sharp. C. 1081.
philpotti Broun. B. 1, ii, 95.
proprius Broun. B. 1, iii, 174.
planiceps Broun. B. 1, iv, 315.
discalis Broun. B. 1, vi, 525.
uropterus Broun. T. xliv, 418.
wallacei Broun. T. xliv, 419.
plagiatus Broun. T. xliii, 98.
affinis Broun. B. 1, viii, 683.
aemulus Broun. B. 1, viii, 684.
Phormesa Pascoe, 1863.
costicollis Reitter. B. 1, i, 38.
Notoulus Broun, 1886 (substituted for *Ablabus*).
ornatus Broun. C. 184.
pallidipictus Broun. C. 185.
scabrus Broun. C. 185.
fervidulus Broun. C. 186.
punctipennis Broun. C. 186.
brevis Broun. C. 763.
nodosus Broun. C. 894.
sparsus Broun. C. 947.
libentus Broun. C. 947.
facetus Broun. C. 1341.
varicornis Broun. B. 1, i, 38.
crassulus Broun. B. 1, ii, 96.
truncatus Broun. B. 1, iii, 175.
longipes Broun. B. 1, iii, 176.
discors Broun. B. 1, vi, 526.
demissus Broun. T. xliv, 419.
sellata Sharp. C. 1081.
Allobitoma Broun, 1919.
halli. B. 1, vi, 527.
Bitoma Herbst, 1793.
insularis White. C. 192.
vicina Sharp. C. 193.
distans Sharp. C. 193.
rugosa Sharp. C. 193.
nana Sharp. C. 194.
distincta Broun. C. 194.
discoidea Broun. C. 195.
lobata Broun. C. 833.
scita Broun. C. 895.
guttata Broun. C. 895.
auriculata Sharp. C. 1082.
serraticula Sharp. C. 1083.
mundula Sharp. C. 1083.

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Bitoma—continued.
picicorne Broun. A. 8, iii, 285.
obsoleta Broun. B. 1, iii, 176.
maura Broun. T. xliv, 420.
morosa Broun. B. 1, vii, 613.
Coxelus Latreille, 1829.
dubius Sharp. C. 196.
similis Sharp. C. 196.
robustus Broun. C. 197.
clarus Broun. C. 766.
grossanus Broun. C. 927.
chalmeri Broun. C. 949.
rufus Broun. C. 1084.
posticalis Broun. C. 1084.
ovicollis Broun. C. 1084.
longulus Broun. C. 1085.
oculator Broun. C. 1342.
picicornis Broun. C. 1342.
graniceps Broun. C. 1343.
regularis Broun. C. 1440.
thoracicus Broun. A. 6, xv, 194.
helmsi Reitter. B. 1, i, 37.
elongatus Broun. A. 8, iii, 386.
variegatus Broun. A. 8, iii, 387.
bicavus Broun. A. 8, iii, 388.
instabilis Broun. B. 1, iii, 177.
mucronatus Broun. T. xliii, 98.
Heterargus Sharp, 1886.
rudis Sharp. C. 1086.
serricollis Broun. C. 1441.
subaequus Broun. B. 1, ii, 97.
parallelus Broun. B. 1, iii, 178.
Gathocles Broun, 1893.
nodosus Broun. C. 1086.
obliquicostatus Broun. A. 8, iii, 388
angulifer Broun. B. 1, iii, 178.
fuscus Broun. B. 1, viii, 684.
interruptus Broun. B. 1, viii, 685
Vitiacus Broun, 1893.
costatus Broun. C. 1087.
costicollis Broun. C. 1442.
incertus Broun. A. 6, xv, 195.
subcaecus Broun. B. 1, vi, 528.
posticalis Broun. B. 1, vi, 529.
purus Broun. B. 1, vi, 529.
suturalis Broun. B. 1, vi, 530.
lateralis Broun. B. 1, vi, 531.
Enarsus Pascoe, 1866.
bakewellii Pascoe. C. 199.
wakefieldi Sharp. C. 199.
rudis Sharp. C. 200.
contractifrons Broun. C. 200.
probus Broun. C. 1088.
cucullatus Sharp. C. 1089.
Rhitidinotus Broun, 1880.
squamulosus Broun. C. 204.
Syncalus Sharp, 1876.
optatus Sharp. C. 201.
politus Broun. C. 201.
hystrix Sharp. C. 202.
piciceps Broun. C. 1092.
monroi Broun. C. 1442.
explanatus Broun. T. xliv, 417.
solidus Broun. B. 1, viii, 685.
Acosmetus Broun, 1880.
oblongus Broun. C. 197.
granulatus Broun. C. 197.
Protarphius Broun, 1893.
ruficornis Broun. A. 6, xii, 184.
indentatus Broun. A. 6, xii, 185.
crassus Broun. C. 669.
decorus Broun. B. 1, ii, 97.
tricavus Broun. A. 8, iii, 389.
posticalis Broun. A. 8, iii, 390.
palleus Broun. B. 1, iii, 179.
Recyntus Broun, 1886.
exiguus Broun. C. 765.
tuberculatus Broun. C. 191.
insignis Broun. C. 191.
salebrosus Broun. C. 192.
reitteri Broun. B. 1, viii, 686.
Symphysius Broun, 1909.
serratus Broun. A. 8, iii, 391.
lobifer Broun. A, 8, iii, 392.
Epistranus Sharp, 1876.
lawsoni Sharp. C. 203.
humeralis Broun. C. 203.
parvus Broun. C. 950.
optabilis Broun. C. 1343.
hirtalis Broun. A. 6, xii, 189.
valens Broun. C. 670.
sharpi Reitter. B. 1, i, 37.
fulvus Reitter. B. 1, i, 37.
Norix Broun, 1893.
crassus Broun. C. 1091.
Glenentela Broun. 1893.
serrata Broun. C. 1090.
costata Broun. B. 1, vi, 527.
Ithris Pascoe, 1864.
gracilis Sharp. C. 205.
Rhizonium Sharp, 1877.
antiquum Sharp. C. 206.
Chorasus Sharp, 1882.
subcaecus Sharp. C. 1093.
Archaeoglenes Broun, 1893.
costipennis Broun. A. 6, xii, 189.
Lithostygnus Broun, 1886.
costatus Broun. C. 950.
serripennis Broun. B. 1, iii, 185.
cuneiceps Broun. B. 1, iii, 186.
Ciconissus Broun, 1893.
granifer Broun. A. 6, xii, 186.

Subfamily BOTHRIDERINAE.

Bothrideres Erichson, 1845.
moestus Sharp. C. 207.
cognatus Sharp. C. 1096.
obsoletus Broun. A. 6, xv, 196.
picipes Broun. A. 7, xi. 618.
diversus Broun. T. xliv, 422.
paynteri Broun. T. xliii, 100.

Subfamily PYCNOMERINAE.

Pycnomerus Erichson, 1842.
sophorae Sharp. C. 208.
simulans Sharp. C. 209.
simplex Broun. C. 209.

Group CLAVICORNES—*continued.*

Pycnomerus—continued.
minor Sharp. C. 209.
ellipticus Broun. C. 210.
rufescens Broun. C. 766.
basalis Broun. C. 766.
carinellus Broun. C. 896.
caecus Broun. C. 896.
hirtus Broun. C. 897.
lateralis Broun. C. 897.
arboreus Broun. C. 927.
cognatus Broun. C. 951.
marginalis Broun. C. 1093.
sinuatus Broun. C. 1094.
impressus Broun. C. 1094.
longulus Sharp. C. 1095.
helmsi Sharp. C. 1095.
sulcatissimus Sharp. C. 1095.
latitans Sharp. C. 1096.
angulatus Broun. C. 1443.
frontalis Broun. C. 1443.
elongellus Broun. C. 1444.
longipes Broun. C. 1444.
depressiusculus White. *Voy. Ereb. and Terr., Ins.*, 18.
nitiventris Broun. A. 7, xi, 617.
arcuatus Broun. B. 1, ii, 98.
ocularius Broun. B. 1, ii, 99.
suteri Broun. A. 8, iii, 393.
ruficollis Broun. A. 8, iii, 394.
tenuiculus Broun. B. 1, iii, 180.
reversus Broun. T. xliv, 421.
candidus Broun. T. xliv, 421.
mediocris Broun. T. xliii, 99.
parvulus Broun. B. 1, vii, 614.
Pycnomerodes Broun, 1886.
peregrinus Broun. C. 952.

Subfamily Ceryloninae.

Philothermus Aubé, 1843.
nitidus Sharp. C. 211.
sanguineus Broun. C. 211.
notabilis Broun. C. 211.
bicavus Reitter. B. 1, i, 39.

Family HISTERIDAE.

Platysoma Leach, 1817.
**bakewelli* Marseul. C. 161.
cinnamoneus White. C. 161.
Sternaulax Marseul, 1862.
zealandicus Marseul. C. 162.
Epierus Erichson, 1834.
sylvanus Broun. C. 163.
purus Broun. C. 163.
abrogatus Broun. C. 892.
planiceps Broun. C. 892.
crenulatus Broun. C. 892.
simplex Broun. C. 893.
rusticus Broun. C. 893.
rufescens Reitter. B 1, i, 24.
spinellus Broun. B. 1, vii, 612.
Saprinus Erichson, 1834.
pseudocyaneus White. C. 164.
punctulipennis Broun. C. 165.
latipes Broun. C. 666.
Pachylopus Erichson, 1834.
pedator Sharp. C. 165.
lepidulus Broun. C. 665.
Abraeus Leach, 1817.
brouni Lewis. C. 166.
vividulus Broun. C. 166.
brunneus Broun. C. 666.
phyllobius Broun. B. 1, ii, 101.
Carcinops.
**14-striata* Stephens.

Family NITIDULIDAE.

Brachypeplus Erichson, 1842.
brevicornis Sharp. C. 168.
Epuraea Erichson, 1843.
antarctica White. C. 169.
zealandica Sharp. C. 169.
signata Broun. C. 169.
Homepuraea Broun, 1893.
amoena Broun. C. 171 and 1073.
Nitidula Fabricius, 1775.
lateralis White. C. 170.
abbreviata Fabricius. C. 171.
Soronia Erichson, 1843.
hystrix Sharp. C. 172.
optata Sharp. C. 172.
morosa Broun. C. 1074.
micans Broun. C. 1074.
oculator Reitter. B. 1, i, 24.
Carpophilus.
**hemipterus* Linnaeus.
**mutilatus* Erichson.
Omosita Erichson, 1843.
spinipes Broun. C. 173.
scutellaris Broun. C. 173.
**colon* Linnaeus.
Neocercus Broun, 1919.
electus Broun. B. 1, vi, 523.
Xenoscelis Wollaston, 1864.
prolixus Sharp. C. 174.
Priates Broun, 1881.
optandus Broun. C. 669.
Ips Fabricius, 1776.
minimus Sharp. C. 1078.
Cycluxyra Broun, 1893 (substituted for *Cyclomorpha*).
politula Broun. C. 668.
impressa Broun. B. 1, iv, 314.
Platipidia Broun, 1893.
asperella Broun. C. 1075.
Priasilpha Broun, 1893.
obscura Broun. C. 1078.
Inopria Broun, 1919.
halli Broun. B. 1, vi, 524.
notata Broun. B. 1, vi, 525.

Subfamily Rhizophaginae.

Lenax Sharp, 1877.
mirandus Sharp. C. 175.

Family TROGOSITIDAE.

Trogosita, Olivier, 1790.
affinis White. C. 177.
**mauritanica* Linnaeus.

Group CLAVICORNES—*continued.*

Leperina Erichson, 1844.
nigrosparsa White. C. 178.
brounii Pascoe. C. 178.
sobrina White. C. 178.
wakefieldi Sharp. C. 179.
ambigua Broun. C. 179.
farinosa Broun. C. 179.
shandi Broun. T. xlii, 307.
Promanus Sharp, 1877.
depressus Sharp. C. 180.
auripilus Broun. C. 1079.
subcostatus Broun. A. 8, iii, 232.
pulchellus Broun. B. 1, iv, 314.
Grynoma Sharp, 1877.
fusca Sharp. C. 181.
diluta Sharp. C. 181.
viridescens Broun. C. 893.
regularis Sharp. C. 1079.
varians Broun. C. 1340.
rugosa Broun. C. 1341.
albosparsa Broun. A. 8, iii, 231.
setigera Broun. B. 1, v, 387.
clavalis Broun. B. 1, v, 388.
proxima Broun. B. 1, v, 388.
pallidula Broun. B. 1, v, 389.
Phycosecis Pascoe, 1875.
discoidea Pascoe. C. 359.
atomaria Pascoe. C. 359.

Family LATHRIDIIDAE.

Holoparamecus Curtis, 1833.
lucidus Broun. C. 232.
castaneus Broun. C. 1448.
tenuis Reitter. B. 1, i, 26.
Lathridius Herbst, 1793.
antipodeus White. C. 233.
sculpturatus Broun. C. 233.
marginalis Broun. C. 233.
costulatus Broun. C. 234.
floridus Broun. C. 234.
bifoveatus Broun. C. 834.
castaneus Broun. C. 834.
priopterus Broun. C. 898.
puncticeps Broun. C. 898.
caviceps Broun. C. 1447.
rufifrons Broun. B. 1, iii, 181.
dualis Broun. B. 1, iii, 181.
Corticaria Marsham, 1802.
angusticollis Broun. C. 235.
pubera Broun. C. 235.
fasciata Broun. C. 235.
hirtalis Broun. C. 236.
finitima Broun. C. 236.
variegata Broun. C. 236.
discoidea Broun. C. 236.
obesa Broun. C. 237.
pudibunda Broun. C. 237.
alacer Broun. C. 237.
tarsalis Broun. C. 768.
pacata Broun. C. 899.
erythrocephala Broun. C. 899.
platyptera Broun. C. 899.
semirufa Broun. C. 952.
gilvipes Broun. C. 953.

Corticaria—continued.
amplipennis Broun. C. 1104.
clarula Broun. A. 6, xv, 197.
illustris Reitter. B. 1, i, 26.
longula Broun. B. 1, i, 26.
melasoma Broun. B. 1, i, 27.
terricola Broun. A. 6, xii, 189.
picicornis Broun. B. 1, ii, 100.
unicolor Broun. B. 1, iii, 182.
vagepunctata Broun. B. 1, iii, 182.
castanea Broun. B. 1, iii, 183.
robusta Broun. B. 1, iii, 183.
latulipennis Broun. B. 1, iii, 184.
clavatula Broun. B. 1, iii, 185.
fuscicollis Broun. T. xliv, 423.
Rethusus Broun, 1886.
pictulus Broun. C. 835.
lachrymosus Broun. C. 836.
fulvescens Broun. B. 1, vi, 532.
Diarthrocera Broun, 1893.
formicaephila Broun. C. 1348.
Myromecoxenus.
atomaroides Reitter. B. 1, i, 27.
Monotoma.
**picipes* Herbst.
**sub-A-foveolata* Watson.
**spinicollis* Aubé.
Coniciomus.
**nodifer* Westwood.

Family CUCUJIDAE.

Chaetosoma Westwood, 1851.
scaritides Westwood. C. 767.
Chaetosomodes Broun, 1919.
halli Broun. B. 1, vii, 615.
Diagrypnodes Waterhouse, 1876.
wakefieldi Waterhouse. C. 217.
Dryocora Pascoe, 1868.
howittii Pascoe. C. 218.
Dendrophagus Schönherr, 1809.
umbrinus Smith. *Cat. Coleop. Brit. Mus.*, 12.
capito Pascoe. C. 219.
Parabrontes Redtenbacher, 1867.
silvanoides Redtenbacher. C. 220.
setiger Broun. C. 768.
Cryptamorpha Wollaston, 1854.
brevicornis White. C. 221.
curvipes Broun. C. 221.
suturalis White. C. 222.
lateritia Broun. C. 222.
rugicollis Broun. B. 1, i, 39.
picturatus Reitter. B. 1, i, 39.
Picrotus Sharp, 1886.
thoracicus Sharp. C. 1098.
sanguineus Broun. C. 1098.
pensus Broun. B. 1, i, 40.
Brontopriscus Sharp, 1886.
sinuatus Sharp. C. 1099.
pleuralis Sharp. C. 219.
Cathartocryptus Sharp, 1886.
obscurus Sharp. C. 1100.
Saphophagus Sharp, 1886.
minutus Sharp. C. 1101.
ferrugineus Broun. C. 1102.

Group CLAVICORNES—*continued.*

Tularthrum Broun, 1893.
lineatum Broun. C. 1103.
Thortus Broun, 1893.
ovalis Broun. C. 1345.
Silvanus Latreille.
**surinamensis* Linnaeus.
**unidentatus* Fabricius.

Family CRYPTOPHAGIDAE.

Telmatophilus Heer, 1841.
depressus Sharp. C. 224.
nitens Sharp. C. 224.
olivascens Broun. C. 1104.
vestitus Broun. B. 1, i, 25.
Cryptophagus Herbst, 1792.
australis Redtenbacher. C. 225.
rubellus Broun. C. 225.
rutilus Broun. C. 226.
vestitus Broun. C. 226.
sylvanus Broun. C. 227.
angulifer Broun. C. 227.
hispidulus Broun. C. 227.
discoideus Broun. C. 1345.
distinctus Broun. C. 1346.
tumidus Broun. C. 1445.
obscurus Broun. C. 1446.
anthracinus Broun. C. 1446.
rufescens Blanchard. *Voy. Pole Sud*, iv, 53, pl. 4.
amoenus Broun. T. xliv, 423.
Salltius Broun. 1893.
ruficeps Broun. C. 228 and 1347.
Paramecosoma Curtis, 1833.
maculosum Broun. C. 670.
Micrambina.
helmsi Reitter. B. 1, i, 25.
insignis Reitter. B. 1, i, 25.

Family SCAPHIDIIDAE.

Scaphisoma Leach, 1812.
concinnum Broun. C. 158.
scutellare Redtenbacher. C. 159.
tenellum Pascoe. C. 159.
apicellum Broun. C. 160.
actuosum Broun. C. 664.
Baeocera Erichson, 1845.
rufa Broun. C. 665.
rufipes Broun. C. 833.
fulvicollis Broun. C. 891.
armata Broun. C. 891.
sternalis Broun. B. 1, iii, 173.
Brachynopus Broun, 1881.
latus Broun. C. 664.

Family MYCETOPHAGIDAE.

Typhaea Stephens, 1830.
curvipes Broun. C. 238.
hirta Broun. C. 239.
Triphyllus Latreille, 1829.
integritus Broun. C. 1105.
fuliginosus Broun. C. 228.
substriatus Broun. C. 229.
aciculatus Broun. C. 229.
serratus Broun. C. 229.
punctulatus Broun. C. 230.
Triphyllus—continued.
adspersus Broun. C. 230.
hispidellus Broun. C. 231
constans Broun. B. 1, ii, 100.
pubescens Broun. A. 8, iii, 195.

Family DERMESTIDAE.

Trogoderma Latreille, 1892.
serrigerum Sharp. C. 240.
signatum Sharp. C. 240.
maestum Broun. C. 241.
granulatum Broun. C. 900.
punctatum Broun. C. 953.
suffusum Broun. C. 953.
4-fasciatum Broun. C. 1105.
antennale Broun. C. 1106.
puncticolle Broun. B. 1, iii, 187.
pictulum Broun. T. xliii, 100.
Dermestes, Linnaeus.
* *vulpinus*, Fabricius.
* *lardarius* Linnaeus.
Anthrenus, Geoffroy.
* *musaeorum* Linnaeus.

Family BYRRHIDAE.

Nesodendron Latreille.
ovatum Broun. B. 2, 6.
zealandicum Sharp. B. 2, 6.
seriatum Broun. B. 1, vi, 532.
Curimus Erichson, 1846.
squamiger Broun. B. 2, 7.
striatus Broun. B. 2, 7.
vestitus Broun. B. 2, 8.
zeelandicus Redtenbacher. B. 2, 8
Synorthus Broun, 1910.
sternalis Broun. B. 2, 9.
orbicularis Broun. B. 2, 10.
nigricans Broun. B. 2, 10.
insuctus Broun. B. 2, 10.
nigralis Broun. B. 2, 11.
mixtus Broun. B. 2, 11.
mandibularis Broun. B. 2, 12.
laevigatus Broun. B. 2, 12.
setarius Broun. B. 2, 13.
rotundus Broun. B. 2, 13.
villosus Broun. B. 2, 14.
pygmaeus Broun. B. 2, 14.
anomalus Broun. B. 2, 15.
granulatus Broun. B. 2, 15.
substriatus Broun. B. 1, iii, 187
vesipilus Broun. B. 1, iii, 188.
rectifrons Broun. B. 1, iv, 316
Pedilophorus Steffahny, 1843.
foveigerus Broun. B. 2, 16.
gemmeus Broun. B. 2, 17.
laevipennis Broun. B. 2, 17.
probus Broun. B. 2, 17.
puncticeps Broun. B. 2, 18.
tibialis Broun. B. 2, 18.
creperus Broun. B. 2, 19.
pulcherrimus Broun. B. 2, 19.
picipes Broun. B. 2, 20.
laetus Broun. B. 2, 20.
lewisi Broun. B. 2, 21.
sculpturatus Broun. B. 2, 21.
cognatus Broun. B. 2, 22.

Genus CLAVICORNES—*continued.*

Pedilophorus—continued.
coruscans Pascoe. B. 2, 22.
helmsi Reitter. B. 2, 22.
bryobius Broun. B. 2, 23.
ornatus Broun. B. 1, ii, 102.
aemulator Broun. B. 1, iii, 189.
nigrescens Broun. B. 1, iv, 316.
opaculus Broun. T. xliv, 424.
tumidellus Broun. S. 102.
Liochoria Pascoe, 1875.
huttoni Pascoe. B. 2, 23.
sumptuosa Broun. S. 103.
longula Broun. S. 104.
Cytilissus Broun, 1893.
claviger Broun. B. 2, 24.
Limnichus Latreille, 1829.
decorus Broun. B. 2, 24.
simplex Broun. B. 2, 24.
picinus Broun. B. 2, 25.
nigripes Broun. B. 2, 25.

Family PARNIDAE.

Potaminus Sturm, 1837.
angusticollis Pascoe. C. 248.
Alloparnus Broun, 1893 (substituted for *Parnida*).
agrestis Broun. C. 1107 and 249.
scutellaris Broun. B. 1, i, 11.
Protoparnus Sharp, 1886.
longulus Sharp. C. 1107.

Family ELMIDAE.

Hydora Broun, 1886 (substituted for *Pachycephala*).
picea Broun. C. 672.
nitida Broun. C. 927.
obsoleta Broun. C. 928.
vestita Broun. B. 1, iii, 153.
lanigera Broun. B. 1, iii, 154.
subaenea Broun. B. 1, iii, 154.

Group PECTICORNES.

Family LUCANIDAE.

Lissotes Westwood, 1855.
reticulatus Westwood. C. 255.
rufipes Sharp. C. 1109.
elegans Broun. C. 1110.
squamidorsis White. C. 251.
punctulatus White. C. 251.
planus Broun. C. 252.
stewarti Broun. C. 673.
capito Deyrolle. E. 1873, 339, and T xlii, 308.
abditus Broun. C. 673.
demaresti Deyrolle. *Ann. Soc. Ent. France*, 1881, 239.
helmsi Sharp. C. 770.
ithaginis Broun. C. 1108.
aemulus Broun. C. 1109.
acmenus Lewis. T. xxxiv, 203.
menalcas Westwood. *N.Z. Jour. Sci.*, ii, 221.
philpotti Broun. B. 1, ii, 103.
dispar Broun. T. xlii, 307.
Ceratognathus Westwood, 1838.
helotoides Thomson. C. 254.
alboguttatus Bates. C. 253.
dispar Sharp, C. 1111.
Mitophyllus Parry, 1845.
irroratus Parry. C. 253.
parryanus Hope. C. 253.
marmoratus Watson. *Ent. Mo. Mag.*, xi, 8.
foveolatus Broun. C. 253.
macrocerus Broun. C. 837.
gibbosus Broun. C. 928.
tuberculatus Broun. C. 1111.
cylindricus Broun. A. 6, xv, 199.
angusticeps Broun. A. 6, xv, 199.
fusculus Broun. C. 837.
auriculatus Broun. A. 7, xi, 615.
comognathus Broun. A. 7, xi, 616.
curvideus Broun. A. 7, xiv, 50.
cristatellus Broun. B. 1, v, 391.
reflexus Broun. T. xli, 148.
insignis Broun. B. 1, viii, 687.
Dendroblax White, 1836.
earlianus White. C. 251.

Group LAMELLICORNES.

Family COPRIDAE.

Saphobius Sharp, 1873.
edwardsi Sharp. C. 256.
wakefieldi Sharp. C. 256.
nitidulus Broun. C. 256.
squamulosus Broun. C. 954.
inflatipes Broun. C. 1112.
fuscus Broun. C. 1113.
setosus Sharp. C. 1113.
fulvipes Broun. C. 1114.
Saphobius—continued.
curvipes Broun. C. 1349.
tibialis Broun. A. 6, xv, 198.
laticollis Broun. B. 1, ii, 104.
lepidus Broun. T. xliv, 425.
Onthophagus Latreille.
**granulatus* Boh.
**posticus* Erichson.
Trox Fabricius.
*sp.

Group LAMELLICORNES—*continued.*

Family APHODIIDAE.

Aphodius Illiger, 1798.
exsculptus White. C. 258.
candens Broun. C. 258.
suspectus Sharp. C. 259.
pascoei Sharp. C. 259.
communis Broun. C. 260.
brouni Sharp. C. 260.
fortipes Broun. C. 954.
distans Sharp.
sulcatissimus Broun. T. xliii, 101.
**granarius* Linnaeus.
Proctophanes.
**sculptus* Hope.
Phycochus Broun. 1886.
graniceps Broun. C. 771.
lobatus Broun. C. 1114.

Family MELOLONTHIDAE.

Stethaspis Hope, 1837.
suturalis Hope. C. 261.
prasinus Broun. C. 1115.
Costleya Broun, 1886.
discoidea Broun. C. 1116.
simmondsi Broun. T. xliv, 427.
Poecilodiscus Broun, 1895.
pulcher Broun. A. 6, xv, 202.
Scythrodes Broun, 1886.
squalidus Broun. C. 955, and A. 7, xix 59.
Xylostygnus Broun, 1886.
piceus Broun. C. 956.
brookesi Broun. B. 1, vi, 534.
Psilodontria Broun, 1895.
viridescens Broun. A. 6, xv, 201.
Mycernus Broun, 1904.
elegans Broun. A. 7, xiv, 52.
Pyronota Hope, 1837.
festiva Fabricius. C. 262.
laeta Fabricius. C. 262.
edwardsi Sharp. C. 263.
sobrina Sharp. C. 263.
munda Sharp. C. 264.
electa Broun. C. 1116.
regalis Broun. C. 1116.
dives Broun. C. 1117.
aurata Broun. C. 1117.
purpurata Broun. C. 1117.
caerulea Broun. C. 1117.
lugubris Sharp. C. 1118.
pallida Broun. C. 1118.
Heteronyx Guerin-Meneville, 1830.
pumilus Sharp. C. 264.
Eusoma White, 1846.
rossii White. C. 268.
costella Broun. C. 269.
aenealis Broun. A. 8, iii, 397.
eximia Broun. B. 1, v, 389.
piliventris Broun. B. 1, vii, 616.
Sericospilus Sharp, 1882.
advena Sharp. C. 1119.
Prodontria Broun, 1904.
lewisi Broun. A. 7, xiv, 54.
Odontria White, 1846.
striata White. C. 265.
suavis Broun. C. 266.
punctulata Broun. C. 266.
cinnamonea White. C. 267.
xanthosticta White. C. 267.
sandageri Broun. C. 929.
albonotata Broun. C. 1118.
smithii Broun. C. 1450.
piciceps Broun. C. 1450.
epomeas Lewis. T. xxxv, 272.
occiputalis Broun. C. 1451.
marmorata Broun. C. 1451.
fusca Broun. C. 1452.
glabrata Broun. C. 1452.
obscura Broun. A. 6, xv, 203.
zealandica White. C. 270.
brunnea Broun. C. 270.
sylvatica Broun. C. 268.
praelatella Broun. A. 8, iii, 400.
puncticollis Broun. B. 1, iv, 317.
obsoleta Broun. B. 1, v, 390.
halli Broun. B. 1, vi, 533.
nitidula Broun. T. xliv, 425.
monticola Broun. T. xliv, 426
similis Broun. T. xliv, 427.
longitarsis Broun. S. 105.
nesobia Broun. B. 1, vii, 615.
Lewisiella, Broun, 1909.
modesta Broun. A. 8, iii, 399.
capito Broun. A. 8, iii, 400.

Family DYNASTIDAE.

Pericoptus Burmeister, 1847.
truncatus Fabricius. C. 271.
punctatus White. C. 272.
stupidus Sharp. C. 272.
nitidulus Broun. C. 273.
frontalis Broun. A. 7, xiv, 55.

Group SERRICORNIA.

Family BUPRESTIDAE.

Nascio Castelnau and Gory, 1835.
eremita White. C. 276.
enysi Sharp. C. 276.
Buprestis Linnaeus.
**lauta* Leconte.
Stigmodera.
**gulielmi* White.

Family EUCMENIDAE.

Neocharis Sharp, 1877.
varia Sharp. C. 277.
pubescens Sharp. C. 278.
simplex Sharp. C. 278.
concolor Sharp. C. 278.
osculans Broun. C. 674.
lobitarsis Broun. B. 1, i, 27.

Group SERRICORNIA—*continued.*

Talerax Sharp, 1877.
distans Sharp. C. 279.
capax Broun. C. 674.
niger Broun. C. 675.
rusticus Broun. C. 675.
foveatus Broun. C. 676.
tenuis Broun. C. 772.
micans Broun. C. 1350.
spinitarsis Broun. B. 1, i, 28.
dorsalis Broun. T. xliv, 428.
Drasterius Eschscoltz, 1829.
nigellus White. C. 279.
Melanus Broun, 1881.
sculptus Broun. C. 677.
Agalba Broun, 1893.
ruficornis Broun. C. 1120.
nigrescens, Broun. C. 1121.
cylindrata Broun. C. 771.

Family ELATERIDAE.

Protelater Sharp, 1877.
elongatus Sharp. C. 305.
huttoni Sharp. C. 305.
guttatus Sharp. C. 305.
picticornis Sharp. C. 306.
opacus Sharp. C. 306.
nigricans Sharp. C. 772.
vitticollis Broun. C. 956.
atriceps Broun. C. 957.
urquharti Broun. C. 1121.
costiceps Broun. C. 1121.
pubescens Broun. C. 1122.
diversus Broun. T. xliv, 428.
Geranus Sharp, 1877.
collaris Pascoe. C. 302.
lineicollis White. C. 304.
fulvus Sharp. C. 303.
similis Sharp. C. 303.
Parinus Sharp, 1877.
villosus Sharp. C. 301.
Corymbites Latreille, 1834.
antipodus Candèze. C. 299.
dubius Sharp. C. 299.
strangulatus White. C. 300.
myops White. C. 300.
olivascens White. C. 300.
agriotoides Sharp. C. 301.
irregularis Sharp. C. 1128.
mundus Sharp. C. 1129.
canaliculatus Broun. C. 1129.
munroi Broun. C. 1130.
fulvescens Broun. T. xliv, 429.
vitticollis Broun. T. xliv, 630.
approximans Broun. T. xliv, 430.
sternalis Broun. T. xliv, 431.
Asymphus Sharp, 1886.
insidiosus Sharp. C. 1132.
Agriotes Eschscholtz.
**lineatus* Linnaeus.
Exoeolus Broun, 1893.
rufescens Broun. C. 1134.
punctatus Broun. C. 1134.
obsoletus Broun. C. 1135.
Ochosternus Candèze, 1863.
zealandicus White. C. 298.
parryi Candèze. *Mon.*, iv, 447.
Chrosis Candèze 1863.
polita Sharp. C. 296.
reversa Sharp. C. 297.
barbata Candèze. C. 297.
elongata Sharp. C. 298.
livens Broun. C. 681.
valida Broun. C. 681.
setigera Broun. C. 682.
brevicollis Broun. C. 682.
castanea Broun. C. 683.
certa Broun. C. 683.
fulvipes Broun. C. 683.
impressa Broun. C. 1133.
aeneola Candèze. *Mem. Belg.*, xvii, 1865, 54.
eximia Broun. A. 6, xii, 288.
dubitans Broun. T. xliv, 429.
Cryptohypnus Eschscholtz, 1833.
powelli Sharp. C. 295.
humilis Sharp. C. 295.
frontalis Sharp. C. 295.
longicornis Sharp. C. 296.
thoracicus Sharp. C. 296.
meinertzhageni Broun. C. 680.
montanus Broun. C. 773.
sandageri Broun. C. 774.
pallipes Sharp. C. 1122.
picticornis Broun. C. 1122.
monticola Broun. C. 1124.
sternalis Broun. C. 1124.
basalis Broun. C. 1125.
fuscipennis Broun. C. 1125.
attenuatus Broun. C. 1453.
deterius Broun. C. 1454.
Oxylasma Broun, 1881.
pannosum Broun. C. 679.
tectum Broun. C. 680.
basale Broun. C. 957.
carinale Broun. C. 1130.
vittiger Broun. C. 1452.
Silene Broun, 1893.
brunnea Broun. C. 1136.
Monocrepidius Eschscholtz, 1829.
**exsul* Sharp. C. 294.
subrufus Broun. C. 294.
maritimus Broun. C. 1135.
Mecastrus Sharp, 1877.
convexus Sharp. C. 293.
vicinus Sharp. C. 293.
discedens Sharp. C. 293.
lateristrigatus White. C. 306.
intermedius Broun. C. 1128.
Zeaglophus Broun, 1895.
pilicornis Broun. A. 6, xv, 235.
Lomemus Sharp, 1877.
pilicornis Sharp. C. 290.
pictus Sharp. C. 290.
suffusus, Sharp. C. 291.
flavipes Sharp. C. 291.
similis Sharp. C. 291.
obscuripes, Sharp. C. 292.

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Lomemus—continued.
elegans Sharp. C. 292.
collaris Sharp. C. 292.
rectus Broun. C. 774.
vittatus Broun. C. 775.
fulvipennis Broun. C. 1126.
fuscicornis Broun. C. 1126.
maurus Broun. C. 1127.
sculpturatus Broun. C. 1127.
frontalis Broun. C. 1128.
fuscipes Broun. C. 1454.
puncticollis Broun. A. 6, xv, 234.
vittipennis Broun. B. 1, i, 29.
Lacon.
**variabilis* Candèze.
Psorochroa Broun, 1886.
granulata Broun. C. 773.
Aglophus Sharp, 1877.
modestus Sharp. C. 289.
Panspoeus Sharp, 1877.
guttatus Sharp. C. 288.
tenebrosus Broun. C. 288.
Betarmon Kiesenwetter, 1858.
gracilipes Sharp. C. 287.
frontalis Sharp. C. 287.
laetus Sharp. C. 287.
obscurus Sharp. C. 287.
flavipilus Broun. C. 1350.
Amphiplatys Sharp, 1877.
lawsoni Sharp. C. 286.
Metablax Sharp, 1877.
brouni Sharp. C. 284.
acutipennis White. C. 284.
approximans White. C. 285.
cinctiger White. C. 285.
Thoramus Sharp, 1877.
wakefieldi Sharp. C. 280.
rugipennis Broun. C. 281.
feredayi Sharp. C. 282.
laevithorax White. C. 282.
perblandus Broun. C. 282.
foveolatus Broun. C. 283.
cervinus Broun. C. 677.
angustus Broun. C. 678.
parvulus Broun. C. 678.
huttoni Sharp. C. 1122.

Genera of Doubtful Position.

Brounia Sharp, 1878.
thoracica Sharp. C. 274.
Byrrhocryptus Broun, 1893.
urquharti Broun. C. 1137.
Amplectopus Sharp, 1886.
ovalis Sharp. C. 1138.
latulus Broun. C. 1351.
fuscus Broun. C. 1351.
pallicornis Broun. C. 1456.
Amychus.
candezei Pascoe. T. ix, 416.

Family DASCILLIDAE.

Byrrhodes Sharp, 1878.
gravidus Sharp. C. 307.
Cyprobius Sharp, 1878.
nitidus Sharp. C. 308.
undulatus Broun. C. 775.
terrenus Broun. A. 6, xv, 236.
Cyphanus Sharp, 1878.
laticeps Sharp. C. 309.
punctatus Sharp. C. 309.
capax Broun. C. 309.
mollis Sharp. C. 310.
debilis Sharp. C. 310.
granulatus Broun. C. 311.
medius Broun. C. 311.
mandibularis Broun. C. 776.
dubius Broun. C. 1139.
scaber Broun. C. 1139.
ocularius Broun. B. 1, i, 29.
maculifer Broun. B. 1, i, 29.
granulosus Broun. B. 1, i, 30.
Atopida White, 1846.
lawsoni Sharp. C. 312.
suturalis White. C. 338.
brouni Sharp. C. 312.
proba Sharp. C. 313.
castanea White. C. 313.
hirta Broun. C. 313.
testacea Broun. C. 314.
dorsalis Broun. C. 1140.
sinuata Broun. C. 1455.
grahami Broun. B. 1, i, 31.
suffusa Broun. B. 1, i, 31.
impressa Broun. B. 1, ii, 105.
villosa Broun. B. 1, vi, 534.
pallidula Broun. B. 1, vi, 535.
montana Broun. B. 1, vi, 536.
basalis Broun. T. xliv, 431.
Veronatus Sharp, 1878.
longicornis Sharp. C. 314.
longipalpis Sharp. C. 315.
sharpi Broun. C. 315.
frontalis Broun. C. 316.
scabiosus Broun. C. 316.
capito Broun. C. 316.
antennalis Broun. C. 776.
nubilus Broun. C. 1455.
amplus Broun. A. 6, xv, 237.
granicollis Broun. B. 1, i, 32.
punctipennis Broun. B. 1, ii, 105.
tarsalis Broun. B. 1, iv, 318.
fulgidulus Broun. B. 1, iv, 318.
sternalis Broun. B. 1, vi, 536.
reversus Broun. B. 1, vi, 537.
apterus Broun. B. 1, vi, 537.
brevicollis Broun. B. 1, vi, 538.
versicolor Broun. B. 1, vi, 539.
vestitus Broun. B. 1, vi, 539.
Mesocyphon Sharp, 1878.
marmoratus Sharp. C. 317.
setiger Sharp. C. 317.
wakefieldi Sharp. C. 318.
divergens Sharp. C. 318.
monticola Broun. C. 958.
granulatus Broun. C. 958.
pallidus Broun. C. 1141.
laticeps Broun. C. 1142.

Group SERRICORNIA—*continued.*

Mesocyphon—continued.
tristis Broun. B. 1, i, 33.
capito Broun. B. 1, ii, 106.
vestitus Broun. B. 1, ii, 106.
longicornis Broun. B. 1, ii, 107.
bifoveatus Broun. B. 1, iii, 189.
lateralis Broun. B. 1, iii, 190.
mandibularis Broun. T. xliv, 432.
Cyphon Paykull, 1798.
huttoni Sharp. C. 320.
parviceps Sharp. C. 320.
pumilio Sharp. C. 320.
arduus Sharp. C. 320.
oscillans Sharp. C. 321.
aequalis Sharp. C. 321.
amplius Broun. C. 322.
viridipennis Broun. C. 322.
graniger Sharp. C. 322.
pictulus Sharp. C. 322.
zealandicus Sharp. C. 323.
suffusus Sharp. C. 323.
laticeps Sharp. C. 323.
genalis Sharp. C. 324.
remotus Broun. C. 776.
nigropictus Broun. C. 777.
laticollis Broun. C. 777.
rectangulus Broun. C. 777.
plagiatus Broun. C. 778.
propinquus Broun. C. 778.
acerbus Broun. C. 778.
crassus Broun. C. 779.
suturalis Broun. C. 779.
nitidus Broun. C. 779.
lateralis Broun. C. 780.
molestus Broun. C. 780.
dilutus Broun. C. 780.
rectalis Broun. C. 837.
waikatoensis Broun. C. 838.
signatus Broun. C. 958.
aethiops Broun. C. 959.
trivialis Broun. C. 959.
pauper Broun. C. 1143.
discedens Broun. C. 1143.
flavescens Broun. C. 1143.
nigritulus Broun. C. 1144.
fuscifrons Broun. C. 1144.
fulvicornis Broun. C. 1144.
ornatus Broun. C. 1145.
variegatus Sharp. C. 1145.
mackerrowi Broun. A. 6, xv, 237.
deterius Broun. B. 1, ii, 107.
cincticollis Broun. B. 1, iv, 319.
granulicollis Broun. B. 1, iv, 320.
plumatellus Broun. B. 1, iv, 320.
burrowsi Broun. B. 1, iv, 320.
pachymerus Broun. T. xliv, 432.
Metriorhynchus.
rufipennis Fabricius.
Cyphotelus Sharp, 1878.
angustifrons Sharp. C. 325.

Family CLERIDAE.

Paupris Sharp, 1877.
aptera Sharp. C. 331.
Metaxina Broun, 1909.
ornata Broun. A. 8, iii, 408.
Parmius Sharp, 1877.
longipes Sharp. C. 331.
debilis Sharp. C. 332.
rugosus Broun. C. 1148.
violaceus Broun. T. xliv, 434.
Pelonium Spinola, 1844.
pustuliferum Westwood. *P.Z.S.*, 1852, 52, pl. 24, fig. 8.
Balcus Sharp, 1877.
niger Sharp. C. 333.
signatus Broun. C. 333.
Eumede Pascoe, 1876.
aeraria Pascoe. C. 334.
Phymatophaea Pascoe, 1876.
electa Pascoe. C. 334.
violacea Fabricius. C. 335.
hilaris Sharp. C. 335.
pantomelas Boisduval. C. 335.
longula Sharp. C. 336.
opiloides Pascoe. C. 336.
fulvipalpis Broun. C. 336.
picta Broun. C. 685.
dorsalis Broun. C. 685.
viridans Broun. C. 686.
testacea Broun. C. 686.
atrata Broun. C. 686.
ignea Broun. C. 784.
opacula Broun. C. 1352.
abnormis Broun. B. 1, i, 37.
sculptipennis Broun. B. 1, ii, 108.
fuscitarsis Broun. B. 1, ii, 109.
breviclava Broun. B. 1, ii, 109.
lugubris Broun. A. 8, iii, 405.
apicale Broun. A. 8, iii, 406.
o'connori Broun. B. 1, iii, 194.
griseipennis Broun. T. xliv, 433.
hudsoni Broun. B. 1, viii, 688.
nigricornis Broun. B. 1, viii, 689.
brevicollis Broun. B. 1, viii, 689.
formosa Broun. B. 1, viii, 689.
Mathesis Waterhouse, 1877.
guttigera Waterhouse. E. 1877, 8.
Necrobia Oliver.
**ruficollis,* Fabricius.
**rufipes* De Geer.

Family MELYRIDAE.

Dasytes Paykull, 1798.
subcyaneus Broun. C. 328.
wakefieldi Sharp. C. 329.
cinerohirtus Broun. C. 329.
obscuricollis Broun. C. 330.
laticeps Broun. C. 330.
stewarti Broun. C. 684.
constrictus Broun. C. 781.
occiputalis Broun. C. 782.
cheesemani Broun. C. 902.
opaculus Broun. C. 202.
helmsi Sharp. C. 1147.
oreocharis Broun. C. 1148.
littoralis Broun. C. 1351.
aethiops Broun. C. 1352.

Group SERRICORNIA—*continued.*

Dasytes—continued.
nigripes Broun. A. 6, xv, 238.
veronicae Broun. B. 1, i, 36.
laevulifrons Broun. B. 1, ii, 109.
aurisetifer Broun. A. 8, iii, 404.
anacharis Broun. A. 8, iii, 405.
fuscitarsis Broun. B. 1, iii, 192.
philpotti Broun. B. 1, iv, 321.
pittensis Broun. T. xliii, 101.
violascens Broun. B. 1, vii, 617.
clavatus Broun. B. 1, vii, 617.
Arthracanthus Broun, 1886.
planifrons Broun. C. 781.
fulvipes Broun. B. 1, iii, 192.
fossicollis Broun. B. 1, iii, 193.
atriceps Broun. B. 1, iii, 193.
foveicollis Broun. T. xliv, 433.
Halyles Broun, 1886.
nigrescens Broun. C. 783.
brevicornis Broun. C. 783.
semidilutus Broun. C. 783.

Family TELEPHORIDAE.

Asilis Broun, 1893.
fulvithorax Broun. C. 326.
nigricans Broun. C. 327.
subnudus Broun. C. 327.
tenuiculus Broun. C. 327.
striatus Broun. C. 328.
tumidus Broun. C. 684.
piliventer Broun. C. 684.
laevigatus Broun. C. 901.
coloratus Broun. C. 1147.
collaris Broun. B. 1, i, 33.
brevicornis Broun. B. 1, i, 34.
opaculus Broun. B. 1, i, 34.
egmontensis Broun. B. 1, i, 35.
punctipennis Broun. B. 1, i, 35.
parallelus Broun. B. 1, i, 36.
pilicornis Broun. A. 8, iii, 401.
sinuellus Broun. A. 8, iii, 402.
granipennis Broun. A. 8, iii, 402
interstitialis Broun. A. 8, iii, 403.
apicalis Broun. A. 8, iii, 404.
flavipennis Broun. B. 1, iii, 191.

Family PTINIDAE.

Subfamily Ptininae.

Ptinus Linnaeus, 1767.
speciosus Broun. C. 338.
murinus White. C. 338.
pilosus White. C. 338.
littoralis Broun. C. 1353.
plagiatus Broun. B. 1, iii, 194.
**fur* Linnaeus.
**tectus* Boisduval.

Subfamily Anobiinae.

Anobium Fabricius, 1775.
amplicolle Broun. C. 339.
Anobium—continued.
ruficorne Broun. C. 340.
tricostellum White. C. 341.
undulatum Broun. C. 687.
inaequale Broun. T. xliv, 434.
niticolle Broun. T. xliv, 435.
**tesselatum* Linnaeus.
**domesticum* Linnaeus.
**paniceum* Linnaeus.
Xenogonus Broun, 1882.
notatus Broun. C. 340.
granulatus Broun. C. 341.
sericeus Broun. C. 341.
pullus Broun. C. 688.
furcus Broun. C. 689.
versutus Broun. C. 689.
plagiatus Broun. C. 689.
ambiguus Broun. C. 689.
Ochina Sturm, 1837.
vulgata Broun. C. 342.
Sphindoteles Broun, 1881.
atriventris Broun. C. 687.
Methemus Broun, 1903.
griseipilus Broun (*Capnodes*). C. 690.
Dorcatoma Herbst, 1790.
oblonga Broun. C. 343.
illustris Broun. C. 343.
lauta Broun. C. 690.
Euderia Broun, 1880.
squamosa Broun. C. 344.

Family BOSTRICHIDAE.

Apate Fabricius, 1775.
minuta Fabricius. C. 346.
Lyctus.
**brunneus* Stephens.

Family CIOIDAE.

Cis Latreille, 1796.
undulatus Broun. C. 347.
assimilis Broun. C. 347.
rufulus Broun. C. 348.
lineicollis Broun. C. 348.
flavitarsis Broun. C. 348.
asperimus Broun. C. 349.
cornuticeps Broun. C. 349.
illustris Broun. C. 349.
perpinguis Broun. C. 350.
anthracinus Broun. C. 350.
picturatus Broun. C. 838.
obesulus Broun. C. 839.
recurvatus Broun. C. 784.
picicollis Broun. C. 785.
viridiflavus Broun. C. 785.
fultoni Broun. C. 904.
piciceps Broun. C. 904.
zeelandicus Reitter. B. 1, i, 41.
Ennearthron Mellie.
boettgeri Reitter. B. 1, i, 41.
obsoletum Reitter. B. 1, i, 41.

Group LONGICORNES.

Family PRIONIDAE.

Prionoplus White, 1846.
reticularis White. C. 566.
Ochrocydus Pascoe, 1876.
huttoni Pascoe. C. 567.

Family CERAMBYCIDAE.

Liogramma Bates, 1874.
zealandica Blanchard. C. 568.
Didymocantha Newman, 1840.
sublineata White. C. 568.
diversicornis White. C. 569.
picta Bates. C. 569.
aegrota Bates. C. 569.
brevicornis Broun. C. 570.
clavipes Broun. C. 808.
robusta Sharp. C. 1271.
quadriguttata Sharp. C. 1272.
jucunda Broun. C. 1272.
binotata Broun. C. 1273.
vittata Broun. C. 1273.
pallida Broun. A. 6, xii, 388.
cognata Broun. B. 1, i, 73.
hudsoni Broun. B. 1, ii, 140.
media Broun. T. xlv, 152.
oedemera Broun. T. xlv, 153.
fuscicollis Broun. T. xlv, 153.
Aemona Newman, 1842.
hirta Fabricius. C. 570 and 1275.
villosa Fabricius. C. 1275.
simplicollis Broun. C. 571 and 1276.
humilis Newman. C. 1274.
inaequalis Sharp. C. 1275.
mutica Sharp. C. 1276.
plicicollis Sharp. C. 1276.
debilis Sharp. C. 1277.
sublineata Broun. A. 8, iv, 281.
separata Broun. B. 1, vii, 659.
Leptachrous Bates, 1874.
strigipennis Westwood. C. 752.
Votum Broun, 1880.
mundum Broun. C. 753.
Pseudocalliprason Broun, 1880.
marginatum White. C. 574.
Ambeodontus.
tristis Fabricius. C. 574.
Agapanthida White, 1846.
pulchella White. C. 575.
scutellaris Pascoe. C. 575.
Ophryops White, 1846.
pallidus White. C. 576.
dispar Sharp. C. 1277.
nigropictus Broun. C. 1278.
testaceus Broun. C. 1278.
lentiginosus Broun. C. 1279.
Pseudosemnus Broun, 1893.
amabilis Broun. C. 1280.
Hesperophanes Mulsant, 1839.
unicolor Fabricius. *Mantissa Insectorum*, 147.
Astetholea Bates, 1874.
pauper Bates. C. 577.
lepturoides Bates. C. 577.
aubreyi Broun. C. 577.
Astetholida Broun, 1880.
lucida Broun. C. 578.
Epheus Broun, 1886.
costifer Broun. C. 871.
Blosyropus Redtenbacher, 1868.
spinosus Redtenbacher. C. 579.
Ptychopterus Broun, 1886.
rugosus Broun. C. 809.
Psilomorpha Saunders, 1850.
tenuipes Saunders. C. 580.
Xuthodes Pascoe, 1875.
punctipennis Pascoe. C. 580.
apicalis Sharp. C. 580.
batesi Sharp. C. 581.
divergens Broun. C. 581.
lepidus Broun. C. 1280.
Calliprason White, 1846.
sinclairi White. C. 582.
Stenopotes Pascoe, 1875.
pallidus Pascoe. C. 583.
Cacodrotus Broun, 1893.
bifasciatus Broun. C. 1281.
Drotus Sharp, 1877.
elegans Sharp. C. 583.
Drototelus Broun, 1903.
politus Broun. A. 7, xii, 82.
Zorion Pascoe, 1867.
minutum Fabricius. C. 584.
guttigerum Westwood. C. 585.
castum Broun. C. 1281.
opacum Sharp. T. xli, 150.
Gnomodes Broun, 1893.
piceus Broun. C. 1282.
Gastrosarus Bates, 1874.
nigricollis Bates. C. 586.
urbanus Broun. C. 1283.
lautus Broun. C. 1283.
picticornis Broun. C. 1284.
Eburida Broun, 1880.
sericea Smith. C. 587.
Acrocyrta Pascoe, 1856.
spinicornis Newman. C. 587.
Clytus Laichorting, 1784.
rugulosus Broun. C. 588.
Coptomma Newman, 1840.
variegatum Fabricius. C. 589.
Navomorpha Blanchard, 1853.
lineatum Fabricius. C. 590.
sulcatum Fabricius. C. 590.
neglectum Broun. C. 591.
sticticum Broun. C. 1284.
Ceresium Newman, 1842.
zealandicum Blanchard. *Voy. Pole Sud*, iv, 272.
Aphanasium Thomson, 1860.
australe Boisduval. *Voy. Astrolabe*, ii, 480.
Phlyctaenodes Newman, 1840.
retifer Lacordaire. *Gen. Col.*, 1869, 374.
Hylotrupes.
**bajulus* Linnaeus.
Phoracantha.
**recurva* Newman.
Callirhoe.
**allaspa* Newman.
Tessaromma.
**undatum* Newman.
**sulcatum.*

Group LONGICORNES—*continued.*

Family LAMIIDAE.

Hexatricha Lacordaire, 1869.
pulverulenta Westwood. C. 592.
heteromorpha Boisduval, *Voy. Astrolabe*, ii, 21.
Xylotoles Newman, 1840.
lynceus Fabricius. C. 593.
griseus Westwood. C. 593.
humeratus Bates. C. 593.
subpinguis White. C. 594.
nudus Bates. C. 594.
rugicollis Bates. C. 594.
inornatus Broun. C. 595.
laetus White. C. 595.
gratus Broun. C. 595.
nanus Bates. C. 596.
aegrotus Bates. C. 597.
pulchellus Bates. C. 597.
scissicauda Bates. C. 597.
bullatus Sharp. C. 598.
pictulus Bates. C. 598.
sandageri Broun. C. 912.
maculosus Broun. C. 913.
angustulus Broun. C. 973.
huttoni Sharp. C. 1287.
abnormalis Sharp. T. xli, 150.
gaudens Broun. C. 1288.
germanus Sharp. C. 1289.
traversi Pascoe. C. 599.
fasciatus Sharp. C. 1289.
phormiobius Broun. C. 1388.
prolongatus Broun. C. 1389.
costatus Pascoe. C. 599.
parvulus White. *Voy. Ereb. and Terror, Insects*, 22.
gracilis Broun. B. 1, i, 75.
schauinslandi Sharp. T. xli, 150.
submicans Broun. B. 1, vii, 659.
apicalis Broun. B. 1, viii, 705.
pygmaeus Broun. B. 1, viii, 705.
Microlamia Bates, 1874.
pygmaea Bates. C. 599.
aemula Broun. C. 810.
Mesolamia Sharp, 1882.
marmorata Sharp. C. 1295.
aerata Broun. C. 1296.
Somatidia Thomson, 1864.
antarctica White. C. 600.
assimilata Broun. C. 600.
terrestris Broun. C. 601.
ptinoides Bates. C. 601.
angusta Broun. C. 601.
pictipes Broun. C. 602.
longipes Sharp. C. 602.
diversa Broun. C. 603.
nitida Broun. C. 603.
crassipes Broun. C. 810.
elongata Broun. C. 811.
grandis Broun. C. 1290.
helmsi Sharp. C. 1290.
spinicollis Broun. C. 1291.
fulvipes Broun. B. 1, viii, 706.
costifer Broun. C. 1291.
variegata Broun. C. 1292.

Somatidia—continued.
simplex Broun. C. 1292.
signata Broun. C. 1293.
convexa Broun. C. 1498.
latula Broun. C. 1499.
laevior Broun. C. 1499.
tenebrica Broun. C. 1500.
albicoma Broun. C. 1500.
proxima Broun. A. 6, xii, 390.
picticornis Broun. A. 6, xv, 418.
testudo Broun. A. 7, xiv, 127.
websteriana Broun. A. 8, iv, 281.
heterarthra Broun. A. 8, iv, 282.
crassicollis Broun. B. 1, viii, 706.
testacea Broun. A. 8, iv, 283.
maculata Broun. B. 1, vi, 587.
sericophora Broun. A. 8, iv, 283.
lineifera Broun. A. 8, iv, 284.
rubella Broun. B. 1, iii, 254.
suturalis Broun. B. 1, iii, 255.
ruficornis Broun. B. 1, iii, 255.
halli Broun. B. 1, iii, 256.
waitei Broun. T. xliii, 113.
vicina Broun. T. xliii, 114.
spectabilis Broun. B. 1, v, 456.
flavidorsis Broun. B. 1, v, 457.
suffusa Broun. B. 1, v, 457.
femoralis Broun. B. 1, v, 458.
oscillans Broun. B. 1, v, 458.
obesula Broun. B. 1, v, 459.
laevinotata Broun. B. 1, v, 460.
parvula Broun. B. 1, v, 461.
longula Broun. B. 1, vi, 588.
vittigera Broun. B. 1, vi, 588.
pennulata Broun. B. 1, vi, 589.
thoracica Broun. T. xlv, 154.
nodularia Broun. T. xlv, 155.
discoidea Broun. T. xlv, 155.
posticalis Broun. T. xlv, 156.
corticola Broun. T. xlv, 156.
pinguis Broun. T. xlv, 157.
placita Broun. B. 1, vii, 660.
origana Broun. B. 1, vii, 661.
oedemera Broun. B. 1, vii, 661.
o'connori Broun. B. 1, vii, 662.
commoda Broun. B. 1, vii, 662.
Stenellipsis, Bates, 1874.
bimaculata White. C. 604.
gracilis White. C. 604.
latipennis Bates. C. 605.
pumila Pascoe. C. 605.
cuneata Sharp. C. 1289.
Psilocnaeia Bates, 1874.
linearis Bates. C. 606.
brouni Bates. C. 606.
Spilotrogia Bates, 1874.
maculata Bates. C. 607.
hilarula Broun. C. 607.
Eurychaena Bates, 1874.
fragilis Bates. C. 608.
feredayi Bates. C. 608.
acutula Broun. C. 608.
Tetrorea White, 1846.
cilipes White. C. 609.

Group LONGICORNES—*continued.*

Tetrorea—continued.
discedens Sharp. C. 1294.
longipennis Sharp. C. 1293.
sellata Sharp. C. 1294.
maculata Broun, T. xlv, 157.
Hybolasius Bates, 1874.
cristus Fabricius. C. 610.
lanipes Sharp. C. 610.
pedator Sharp. C. 610.
wakefieldi Bates. C. 611.
concolor Broun. C. 611.
viridescens Bates. C. 611.
promissus Broun. C. 612.
simplex Bates. C. 612.
modestus Broun. C. 613.
variegatus Broun. C. 613.
cristatellus Bates. C. 614.
bellicosus Broun. C. 614.
pārvus Broun. C. 614.
vegetus Broun. C. 744.
fasciatus Broun. C. 744.
brevicollis Broun. C. 811.
picitarsis Broun. C. 812.
pusillus Broun. C. 812.
apicalis Broun. C. 872.
piceus Broun. C. 872.
deplanatus Sharp. C. 1297.
castaneus Broun. C. 1297.
finitimus Broun C. 1298.
albihirtus Broun. C. 1298.
gnarus Broun. C. 1298.
Hybolasius—continued.
femoralis Broun. C. 1299.
thoracicus Broun. C. 1299.
rufescens Broun. C. 1300.
dubius Broun. C. 1389.
optatus Broun. A. 6, xii, 389.
trigonellaris Hutton. T. xxx, 158.
cognatus Broun. A. 7, xii, 82.
laticollis Broun. A. 7, xii, 83.
gracilipes Broun. A. 7, xii, 84.
genalis Broun. A. 7, xii, 84.
varipes Broun. A. 8, iv, 284.
ciliatus Broun. B. 1, ii, 140.
vittiger Broun. B. 1, ii, 141.
lineiceps Broun. B. 1, iii, 257.
sculpturatus Broun. B. 1, iv, 341.
cupiendus Broun. T. xlv, 158.
tumidellus Broun. T. xlv, 159.
rugicollis Broun. T. xlv, 159.
Poecilippe Bates, 1874.
stictica Bates. C. 615.
flavipes White. C. 615.
medialis Sharp. C. 1301.
femoralis Sharp. C. 1301.
simplex Bates. C. 612.
Diastamerus Redtenbacher, 1868.
tomentosus Redtenbacher. C. 616.
Tympanopalpus Redtenbacher, 1868.
dorsalis Redtenbacher. C. 617.
Adriopea Broun. 1910.
pallidata Broun. B. 1, i, 74.

Group PHYTOPHAGA.

Family CHRYSOMELIDAE.

Subfamily EUMOLPINAE.

Eucolaspis Sharp, 1886.
brunneus Fabricius. C. 622.
pallidipennis White. C. 622.
puncticollis Broun. C. 623.
jucundus Broun. C. 623.
subaeneus Broun. C. 624.
plicatus Broun. A. 8, iv, 285.
sculptus Broun, C. 624.
merus Broun. C. 624.
brevicollis Broun. C. 625.
atroceruleus Broun. C. 625.
ochraceus Broun. C. 1303.
coloratus Broun. C. 1303.
montanus Broun. C. 1304.
vittiger Broun. A. 6, xii, 391.
picticornis Broun. A. 6, xii, 391.
Atrichatus Sharp, 1886.
ochraceus Broun. C. 625 and 1305.
aeneicollis Broun. A. 6, xv, 419.
nitidulus Broun. A. 8, iv, 286.
Pilacolaspis Sharp, 1886.
wakefieldi Sharp. C. 1306.
huttoni Broun. C. 626.
rugiventris Broun. B. 1, iii, 258.
angulatus Broun. T. xlv, 160.
latipennis Broun. T. xlv, 160.
Peniticus Sharp, 1876.
suffusus Sharp. C. 627.
antiquus Sharp. C. 627.
robustus Broun. C. 628.
plicatus Broun. B. 1, vii, 663.

Subfamily CRYPTOCEPHALINAE.

Arnomus Sharp, 1876.
brouni Sharp. C. 619.
curtipes Broun. C. 1390.
marginalis Broun. C. 1390.
viridicollis Broun. A. 8, iv, 286.
signatus Broun. A. 8, iv, 287.
fulvus Broun. B. 1, iv, 342.
vicinus Broun. B. 1, iv, 342.
Alema Sharp, 1876.
paradoxa Sharp. C. 620.
puncticollis Broun. C. 620.
spatiosa Broun. C. 621.
Eualema Broun, 1903.
walkeri Broun. A. 7, xii, 86.
Scaphodius Chapuis, 1874.
compactus Sharp. C. 1302.

Subfamily CHRYSOMELINAE.

Allocharis Sharp, 1882.
marginata Sharp. C. 1306.
morosa Broun. C. 1307.

Group PHYTOPHAGA—*continued.*

Allocharis—continued.
- *limbata* Broun. C. 1307.
- *praestans* Broun. B. 1, v, 462.
- *subsulcata* Broun. B. 1, v, 462.
- *nigricollis* Broun. B. 1, v, 463.
- *picticornis* Broun. B. 1, v, 463.
- *media* Broun. B. 1, v, 463.
- *fuscipes* Broun. B. 1, v, 464.
- *robusta* Broun. B. 1, v, 464.
- *tarsalis* Broun. B. 1, v, 465.

Chalcolampra.
- *speculifera* Sharp. B. 1, i, 77.

Aphilon Sharp, 1876.
- *enigma* Sharp. C. 629.
- *pretiosa* Broun. C. 630.
- *punctata* Broun. C. 630.
- *minuta* Broun. C. 631.
- *monstrosa* Broun. C. 874.
- *sobrina*, Broun. C. 875.
- *praestans* Broun. C. 1309.
- *convexa* Broun. C. 1310.
- *latulum* Broun. C. 1310.
- *scutellaris* Broun. C. 1501.
- *laticollis* Broun. A. 6, xii, 392.
- *impressa* Broun. B. 1, iii, 258.
- *sternalis* Broun. B. 1, vii, 664.

Caccomolpus Sharp, 1886.
- *globosus* Sharp. C. 1308.
- *plagiatus* Sharp. C. 1308.
- *pullatus* Broun. C. 1309.
- *maculatus* Broun. C. 1309.
- *ornatus* Broun. B. 1, i, 77.
- *flectipes* Broun. B. 1, iii, 259.
- *nigristernis* Broun. B. 1, v, 465.
- *hallianus* Broun. B. 1, v, 466.
- *fuscicornis* Broun. B. 1, v, 466.
- *substriatus* Broun. B. 1, v, 467.
- *tibialis* Broun. B. 1, v, 467.
- *viridescens* Broun. B. 1, v, 468.
- *subcupreus* Broun. B. 1, vi, 589.
- *amplus* Broun. B. 1, vi 590.
- *cinctiger* Broun. B. 1, vi, 590.
- *montanus* Broun. B. 1, vii, 665.

Cyrtonogetus Broun, 1915.
- *crassus* Broun. B. 1, iv, 343.

Subfamily Galerucinae.

Luperus Geoffroy, 1764.
- *vulgaris* Broun. C. 632.
- *attenuatus* Broun. C. 633.
- *thoracicus* Broun. C. 633.
- *nigripes* Broun. C. 634.
- *nigricans* Broun. C. 634.
- *nitidicollis* Broun. C. 634.
- *aeneus* Broun. C. 635.
- *viridis* Broun. C. 635.
- *oleareae* Broun. C. 1312.
- *rugicollis* Broun. C. 1313.
- *brevicollis* Broun. C. 1313.
- *sulcifer* Broun. C. 1313.
- *rectipes* Broun. C. 1314.
- *calcaratus* Broun. C. 1314.
- *princeps* Broun. C. 1314.
- *monticola* Broun. C. 1315.
- *fuscatus* Broun. C. 1315.
- *sordidus* Broun. C. 1316.
- *truncatus* Broun. C. 1316.
- *nigricornis* Sharp. C. 1316.

Luperus—continued.
- *aenescens* Sharp. C. 1317.
- *puncticollis* Sharp. C. 1317.
- *mollis* Broun. C. 1502.
- *cheesemani* Broun. B. 1, i, 75.
- *obscurus* Broun. B. 1, i, 76.
- *diversus* Broun. B. 1, i, 76.
- *angularius* Broun. A. 8, iv, 288.
- *scutellaris* Broun. A. 8, iv, 289.
- *lewisi* Broun. A. 8, iv, 289.
- *axyrocharis* Broun. A. 8, iv, 290.
- *palialis* Broun. A. 8, iv, 290.
- *asperellus* Broun. A. 8, iv, 290.
- *insolitus* Broun. B. 1, iii, 260.
- *dilutipes* Broun. B. 1, iv, 344.
- *anthracinus* Broun. B. 1, iii, 260.
- *bullatus* Broun. B. 1, iii, 261.
- *discrepans* Broun. B. 1, iii, 261.
- *dilatatus* Broun. B. 1, iii, 262.
- *iridescens* Broun. B. 1, iii, 263.
- *aurellus* Broun. B. 1, iii, 263.
- *nodicollis* Broun. B. 1, iv, 344.
- *pubicollis* Broun. B. 1, iv, 345.
- *halli* Broun. B. 1, v, 469.
- *dilucidus* Broun. B. 1, v, 470.
- *cyanescens* Broun. B. 1, v, 470.
- *gracilipes* Broun. B. 1, v, 471.
- *minor* Broun. B. 1, v, 471.
- *quadricollis* Broun. B. 1, v, 472.
- *xenoscelis* Broun. B. 1, v, 472.
- *perplexus* Broun. B. 1, v, 473.
- *pygidialis* Broun. B. 1, v, 473.
- *mediocris* Broun. B. 1, v, 474.
- *simmondsi Broun.* T. xlv, 161.
- *foveigerus* Broun. T. xlv 161.
- *o'connori* Broun. T. xlv, 162.
- *atripennis* Broun. T. xlv, 162.

Allastena Broun, 1893.
- *nitida* Broun. C. 1318.
- *quadrata* Broun. C. 1319.
- *piliventris* Broun. B. 1, iv, 346.
- *eminens* Broun. B. 1, v, 468.

Bryobates Broun, 1886.
- *coniformis* Broun. C. 874.
- *aeratus* Broun. B. 1, ii, 141.
- *nigricans* Broun. B. 1, ii, 142.
- *rugidorsis* Broun. B. 1, v, 461.

Subfamily Halticinae.

Trachytetra Sharp, 1886.
- *rugulosa* Broun. C. 636 and 1311
- *frontalis* Broun. B. 1, viii, 707.
- *robusta* Broun. B. 1, viii, 707.

Inopelonia Broun, 1893.
- *testacea* Broun. C. 637.
- *fuliginosa* Broun. C. 637.

Pleuraltica Sharp, 1886.
- *cyanea* Broun. C. 1312 and 638.

Phyllotreta Chevrolat, 1839.
- *nitida* Broun. C. 636.
- *graminicola* Broun. C. 1391.
- *littoralis* Broun. C. 1391.
- *vittigera* Broun. C. 1392.
- *passpalae* Broun. B. 1, viii, 708.

Family BRUCHIDAE.

Bruchus.
- **rufimanus* Bohem.

Group HETEROMERA.

Family TENEBRIONIDAE.

Subfamily OPATRINAE.

Opatrum Fabricius, 1775.
laevigatum Fabricius. *Ent. Syst.*, i, 89, 5.
Pseudopatrum Sharp, 1886.
tuberculicostatum White. C. 353.
sordidum Sharp. C. 1152.
Mesopatrum Broun, 1893.
granulosum Broun. C. 1355.
dubium Broun. B. 1, v, 396.
Periatrum Sharp, 1886.
helmsi Sharp. C. 1153.
tumipes Broun. C. 1456.
Syrphetodes Pascoe, 1875.
marginatus Pascoe. C. 352.
crenatus Broun. C. 352.
decoratus Broun. C. 353.
bullatus Sharp. C. 1150.
sylvius Broun. C. 1150.
cordipennis Broun. C. 1457.
dorsalis Broun. C. 1458.
punctatus Broun. C. 1458.
nodosalis Broun. A. 7, xiv, 56.
simplex Broun. A. 7, xii, 69.
variegatus Broun. B. 1, v, 392.
thoracicus Broun. B. 1, vi, 540.
pensus Broun. B. 1, vi, 540.
truncatus Broun. T. xliv, 435.
Paraphylax Broun, 1880.
squamiger Broun. C. 355.
varius Broun. C. 355.
binodosus Broun. A. 6, xv, 240.
sternalis Broun. A. 7, xiv, 57.
exiguus Broun. B. 1, iii, 195.
Exohadrus Broun, 1893.
volutithorax Broun. C. 356 and 1153.

Subfamily TRACHYSCELINAE.

Chaerodes White, 1846.
trachyscelides White. C. 357.
laetus Broun. C. 358.
concolor Sharp. C. 358.
fuscatus Broun. A. 6, xv, 241.
Actizeta Pascoe, 1875.
ammobioides Pascoe. C. 359.
albata Pascoe. C. 360.

Subfamily DIAPERINAE.

Menimus Sharp, 1876.
batesi Sharp. C. 361.
puncticeps Broun. C. 361.
oblongus Broun. C. 362.
caecus Sharp. C. 362.
crinalis Broun. C. 363.
crassus Sharp. C. 363.
dubius Broun. C. 363.
obscurus Broun. C. 364.
thoracicus Broun. C. 364.
curtulus Broun. C. 785.
piceus Broun. C. 786.
striatulus Broun. C. 842.
sinuatus Broun. C. 842.
vicinus Broun. A. 6, xii, 288.

Menimus—continued.
laevicollis Broun. A. 6, xv, 242.
humeralis Broun. B. 1, i, 41.
aemulator Broun. B. 1, i, 42.
pubiceps Broun. B. 1, vi, 541.
lineatus Broun. T. xliv, 436.
Bolitophagus Illiger, 1798.
angulifer Blanchard. *Voy. Pole Sud*, iv, 167.
Uloma Castelnau, 1840.
tenebrionoides White. C. 366.
laevicostata Blanchard. *Voy. Pole Sud*. iv, 165.
Tenebrio Linnaeus.
**obscuraus* Fabricius.
**molitor* Linnaeus.
Ulomotypus Broun, 1886.
laevigatus Broun. C. 841.
Apthora Bates, 1872.
ruficeps Bates. C. 367.
glabritarsis Sharp. C. 1153.
Cilibe Brême, 1842.
opacula Bates. C. 368.
nitidula Bates. C. 369.
otagensis Bates. C. 370.
elongata Brême. C. 371.
pascoei Bates. C. 372.
humeralis Bates. C. 373.
thoracica Bates. C. 373.
brevipennis Bates. C. 374.
granulosa Brême. C. 375.
rugosa Bates. C. 375.
tibialis Bates. C. 376.
impressifrons Bates. C. 376.
buchanani Broun. C. 377.
huttoni Sharp. C. 378.
marginalis Broun. C. 1155.
phosphugoides White. *Voy. Ereb. and Terr., Insects*, 11.
costella Broun. A. 7, xv, 544.
lateralis Broun. A. 8, iii, 408.
smithiana Broun. A. 8, iii, 409.
saragoides Pascoe. T. xli, 148.
subcostata Sharp. T. xli, 149.
Zolodinus Blanchard, 1853.
zealandicus Blanchard. C. 379.
Lorelus Sharp, 1876.
priscus Sharp. C. 381.
pubescens Broun. C. 381.
crassicornis Broun. C. 382.
quadricollis Broun. C. 786.
latulus Broun. B. 1, i, 43.
tarsalis Broun. B. 1, i, 43.
marginalis Broun. B. 1, i, 43.
sternalis Broun. B. 1, i, 44.
nigrescens Broun. B. 1, i, 45.
Demtrius Broun, 1895.
carinulatus Broun. A. 6, xv, 243.
Arthopus Sharp, 1876.
brouni Sharp. C. 383.
Edalus Broun, 1893.
alienus Broun. C. 391.
opacus Broun. C. 1160.
pleuralis Broun. A. 6, xii, 289.

Group HETEROMERA—*continued.*

Subfamily Cnodaloninae.

Artystona Bates, 1873.
erichsoni Bates. C. 384.
wakefieldi Bates. C. 385.
rugiceps Bates. C. 385.
obscura Sharp. C. 1154.
collaris Sharp. C. 1154.
obsoleta Sharp. C. 1154.
interrupta Redtenbacher. *Reise Novara, Coleop.*, 128.
philpotti Broun. B. 1, i, 45.
tinctella Broun. B. 1, i, 46.
vicina Broun. B. 1, i, 46.

Subfamily Helopinae.

Pheloneis Pascoe, 1866.
harpaloides White. *Voy. Ereb. and Terror, Insects*, 11.
bullatum Pascoe. C. 386.
intricatum Bates. C. 387.
aucklandicum Broun. C. 387.
amaroides White. C. 388.
aeratum Broun. C. 388.
lentum Broun. C. 389.
zealandicum Bates. C. 390.
thoracicum Bates. C. 390.
cheesemani Broun. C. 787.
chalmeri Broun. C. 787.
indagator Broun. C. 839.
rufilabrum Broun. C. 840.
hanseni Broun. C. 929.
nigritulum Broun. C. 930.
multistriatum Sharp. C. 1155.
simplex Sharp. C. 1156.
sericatum Sharp. C. 1156.
intermedium Sharp. C. 1156.
dunedinis Sharp. C. 1157.
urquharti Broun. C. 1157.
miniatum Broun. C. 1157.
gratiosum Broun. C. 1158.
turgidulum Broun. C. 1158.
tuberculatum Guerin. *Voy. Pole Sud*, iv, 175.
simulans Redtenbacher. *Reise Novara*, 32.
femorale Broun. B. 1, i, 48.
titahiense Broun. B. 1, i, 49.
tinctum Broun. B. 1, ii, 111.
calcaratum Broun. B. 1, ii, 110.
hudsoni Broun. A. 8, iii, 411.
appositus Broun. B. 1, iv, 322.
halli Broun. B. 1, v, 392.
angulatus Broun. B. 1, v, 393.
dubitans Broun. B. 1, v, 394.
curtulus Broun. B. 1, v, 394.
complicatum Broun. T. xliv, 437.
Pseudhelops Guérin.
tuberculatus Guérin. S. 106.
quadricollis Broun. S. 107.
posticalis Broun. S. 107.
interruptus Broun. S. 108.
substriatus Broun. B. 1, i, 47.
nodosus Broun. B. 1, i, 47.
Cerodolus Sharp, 1886.
chrysomeloides Sharp. C. 1161.
genialis Broun. C. 1162.
aeneus Broun. C. 1162.
tuberculatus Broun. B. 1, v, 395.
capitalis Broun. B. 1, v, 395.
sulcisternus Broun. B. 1, v, 396.
curvellus Broun. T. xliv, 437.
Leiopeplus Broun, 1893.
expolitus Broun. C. 392 and 1160.

Subfamily Amarygminae.

Amarygmus Dalman, 1823.
zealandicus Bates. C. 394.
Gnathocerus.
**cornutus* Fabricius.
Tribolium.
**ferrugineum* Fabricius.

Family CISTELIDAE.

Amarosoma Redtenbacher, 1868.
metallicus White. C. 395.
sophorae Broun. C. 396.
violacea Broun. B. 1, i, 49.
Xylochus Broun, 1880.
substriatus Broun. C. 397.
tibialis Broun. C. 397.
dentipes Broun. C. 788.
spinifer Broun. C. 1168.
Omedes Broun, 1893.
nitidus Broun. C. 1169.
fuscatus Broun. C. 1170.
apterus Broun. A. 6, xv, 244.

Family LAGRIIDAE.

Lagrioda Fairmaire et Germain, 1860.
brounii Pascoe. C. 408.

Family MELANDRYIDAE.

Ctenoplectron Redtenbacher, 1868.
fasciatum Redtenbacher. C. 401.
fuliginosum Broun. C. 402.
maculatum Broun. C. 691.
costatum Broun. C. 691.
vittatum Broun. C. 844.
coloratum Broun. C. 959.
dignum Broun. C. 960.
Allopterus Broun, 1886.
reticulatus Broun. C. 790.
ornatus Broun. C. 401.
instabilis Broun. C. 844.
cavelli Broun. C. 1356.
simulans Broun. B. 1, i, 52.
Hylobia Broun, 1880.
velox Broun. C. 404.
undulata Broun. C. 404.
nebeculosa Broun. C. 404.
pulla Broun. C. 405.
nigricornis Broun. C. 405.
calida Broun. C. 405.
bifasciata Broun. C. 406.

Group HETEROMERA—*continued.*

Hylobia—continued.
minor Broun. C. 406.
cylindrata Broun. C. 406.
usitata Broun. C. 407.
nigella Broun. C. 407.
sexnotata Broun. B. 1, iv, 324.
acuminata Broun. B. 1, iv, 325.
arboricola Broun. B. 1, iv, 325.
plagiata Broun. T. xliv, 439.
Philpottia Broun, 1915.
maculatus Broun. B. 1, iv, 323.
mollis Broun. C. 960.
Chalcodrya Redtenbacher, 1868.
variegata Redtenbacher. C. 403.
Onysius Broun, 1886.
anomalus Broun. C. 843.
pulcher Broun. C. 1357.
Doxozilora Broun, 1909.
punctata Broun. A. 8, iii, 412.
Axylita Broun, 1914.
sericophora Broun. B. 1, ii, 112.
Allorchesia Broun, 1914.
validipes Broun. B. 1, ii, 113.
guinnessi Broun. T. xliv, 439.
Neorchesia Broun, 1914.
divergens Broun. B. 1, ii, 114.
terricola Broun. B. 1, iii, 197.
Mecorchesia Broun, 1914.
spectabilis Broun. B. 1, ii, 116.
brevicornis Broun. B. 1, ii, 116.
Lyperocharis Broun, 1914.
agilis Broun. B. 1, ii, 118.
Nothotelus Broun, 1914.
ocularius Broun. B. 1, ii, 119.

Family PYTHIDAE.

Salpingus Gyllenhal, 1810.
perpunctatus Broun. C. 398.
bilunatus Pascoe. C. 398.
angusticollis Broun. C. 399.
unguiculus Broun. C. 399.
lautus Broun. C. 400.
hirtus Broun. C. 789.
simplex Broun. C. 789.
quisquilius Broun. C. 789.
fossulatus Broun. C. 1459.
ornatus Broun. A. 6, xv, 245.
cognatus Broun. B. 1, i, 49.
rugulosus Broun. B. 1, i, 50.
tarsalis Broun. B. 1, i, 51.
simplex Broun. B. 1, i, 51.
semilaevis Broun. B. 1, iii, 196.
atrellus Broun. B. 1, iii, 196.
denticollis Broun. B. 1, iii, 196.
aterrimus Broun. B. 1, vi, 542.
nigricans Broun. B. 1, vii, 618.
Agapytho Broun, 1919.
foveicollis Broun. B. 1, vi, 543.

Family ANTHICIDAE.

Subfamily ANTHICINAE.

Cotes Sharp, 1877.
vestita Sharp. C. 411.

Cotes Sharp—continued.
proba Broun. C. 691.
crispi Broun. C. 412.
optima Broun. C. 1165.
punctata Broun. C. 1165.
dorsalis Broun. C. 1166.
distincta Broun. C. 1166.
proxima Broun. C. 1167.
rufa Broun. C. 1167.
insignis Broun. T. xliv, 438.
halliana Broun. B. 1, viii, 690.
bullata Broun. B. 1, viii, 690.
Anthicus Paykull, 1798.
obscuricornis Broun. C. 411.
pellucidipes Broun. C. 412.
minor Broun. C. 930.
anthracinus Broun. C. 1168.
fallax Broun. C. 1168.
flavitarsis Broun. B. 1, ii, 119.
**floralis* Linnaeus.

Subfamily PEDILINAE.

Macratria Newman, 1838.
exilis Pascoe. C. 409.
verticalis Sharp. C. 409.
Scraptogetus Broun, 1893.
anthracinus Broun. C. 1358.

Family OEDEMERIDAE.

Selenopalpus White, 1846.
cyaneus Fabricius. C. 420.
subviridis White. *Voy. Ereb. and Terr., Insects*, 13.
aciphyllae Broun. C. 845.
rectipes Broun. A. 8, iii, 413.
Sessinia Pascoe, 1863.
strigipennis White. C. 420.
latiuscula Broun. C. 421.
lineata Fabricius. C. 421.
pauperata Pascoe. C. 422.
nemoralis Broun. C. 845.
longicornis Broun. C. 1459.
thoracica Broun. A. 6, xii, 290.
reversa Broun. A. 6, xii, 291.
stictica Broun. B. 1, iii, 199.
brookesi Broun. B. 1, v, 397.
Thelyphassa Pascoe, 1876.
diaphana Pascoe. C. 422.
obscura Broun. C. 422.
conspicua Broun. C. 790.
limbata Broun. C. 961.
fuscata Broun. A. 7, xii, 70.
longicollis Broun. A. 7, xii, 70.
Dammarobius Broun, 1886.
mollis Broun. C. 846.
Baculipalpus Broun, 1880.
rarus Broun. C. 423.
maritimus Broun. A. 8, iii, 414.
Exocalopus Broun, 1893.
pectinatus Broun. C. 1170.
antennalis Broun. A. 7, xii, 71.
nitidiceps Broun. B. 1, i, 53.
Phytilea Broun, 1893.
propera Broun. C. 1172.

Group HETEROMERA—*continued.*

Techmessa Bates, 1874.
concolor Bates. C. 424.
telephoroides Bates. C. 424.
attenuata Broun. C. 1172.
varians Broun. C. 1173.
rugicollis Broun. B. 1, i, 52.
longicollis Broun. A. 7, xii, 70.
Techmessodes Broun, 1893.
picticornis Broun. C. 424.
versicolor Broun. C. 1173.
cephalotes Broun. B. 1, i, 53.
Metasclera Broun, 1914.
nigricans Broun. B. 1, iii, 198.
arborea Broun. B. 1, iii, 198.
Nacerdes.
**melanura* Schmidt.

Family MORDELLIDAE.

Subfamily Mordellinae.

Mordella Linnaeus, 1758.
antarctica White. *Voy. Ereb. and Terror, Insects*, 12.
funerea Pascoe. C. 414.
tibialis Broun. C. 414.
Mordella—continued.
detracta Pascoe. C. 414.
tairuensis Broun. C. 414.
Mordellistena Costa, 1855.
jucunda Broun. C. 415.
neglecta Broun. C. 415.
Zeamordella Broun, 1880.
monacha Broun. C. 847.
Apeosina Broun, 1881.
stewarti Broun. C. 693.
tener Broun. C. 693.
Cryptomera Broun, 1893.
nigra Broun. C. 1359.

Subfamily Rhipiphorinae.

Rhipistena Sharp, 1878.
lugubris Sharp. C. 417.
cryptarthra Broun. A. 7, xiv, 58.
sulciceps Broun. A. 7, xiv, 59.
Allocinops Broun, 1919.
brookesi Broun. B. 1, vii, 619.
Sharpia Broun, 1880 (not of Tournier, 1873).
hirtella Broun. C. 418.
Xylophilus.
xenarthrus Broun. B. 1, i, 54.

Group RHYNCHOPHORA.

Family BRENTHIDAE.

Teramocerus.
barbicornis Fabricius. C. 544.
cylindricornis Fabricius C. 543.

Family ANTHRIBIDAE.

Anthribus Geoffroy, 1762.
spinifer Sharp. C. 545.
sharpi Broun. C. 546.
brouni Sharp. C. 547.
halli Broun. B. 1, vi, 586.
sandageri Broun. C. 1261.
obsoletus Broun. C. 1262.
rudis Sharp. C. 547.
bullatus Sharp. C. 548.
vates Sharp. C. 548.
inornatus Sharp. C. 1255.
concolor Sharp. C. 1256.
brunneus Broun. C. 1262.
flavipilus Broun. A. 6, xv, 417.
tessellatus Broun. C. 1263.
curvatus Broun. C. 1263.
lanuginosus Broun. C. 549.
phymatodes Redtenbacher. C. 550.
fuscopictus Broun. C. 564.
hetaera Sharp. C. 550.
discedens Sharp. C. 551.
tuberosus Sharp. C. 1254.
altus Sharp. C. 551.
ornatus Sharp. C. 552.
huttoni Sharp. C. 553.
decens Broun. C. 1264.
Anthribus—continued.
finitimus Broun. C. 1264.
anxius Broun. C. 1265.
laetabilis Broun. C. 1265.
deterius Broun. C. 1266.
impar Broun. C. 1266.
picipictus Broun. C. 742.
nigrescens Broun. C. 743.
torulosus Broun. C. 743.
crassus Sharp. C. 560.
nanus Sharp. C. 561.
atomus Sharp. C. 561.
purpureus Broun. C. 559.
minor Broun. C. 1260.
fungicola Broun. C. 1261.
thoracicus Broun. C. 1261.
cucullatus Sharp. C. 1255.
anguliceps Broun. B. 1, i, 72.
rugifer Broun. B. 1, i, 72.
maurus Broun. B. 1, i, 72.
suspectus Broun. B. 1, i, 73.
albiceps Broun. B. 1, ii, 138.
imitarius Broun. B. 1, ii, 139.
lewisi Broun. A. 8, iv, 159.
philpotti Broun. A. 8, iv, 160.
venustus Broun. B. 1, iii, 254.
cornutellus Broun. T. xlv, 150.
levinensis Broun. T. xlv, 150.
obscurus Broun. T. xlv, 151.
wairirensis Broun. T. xlv, 152.
cristatellus Broun. T. xliii, 111.
propinquus Broun. T. xliii, 112.
pilicornis Broun. T. xliii, 112.

Group RHYNCHOPHORA—*continued.*

Exilis Pascoe, 1873 (=*Lawsonia* Sharp).
lawsoni Sharp. C. 556.
variabilis Sharp. C. 557.
Arecopais Broun, 1893.
spectabilis Broun. C. 558.
Proscoporhinus Montrouzier, 1860.
meinertzhageni Broun. C. 563.
signatus Broun. C. 1268.
viridescens Broun. C. 1269.
albifrons Sharp. C. 1269.
Etnalis Sharp, 1873.
spinicollis Sharp. C. 554.
Eugonissus Broun. C. 1893.
pictipes Broun. C. 1257.
conulus Broun. C. 555.
proximus Broun. C. 555.
obtusus Sharp. C. 1256.
turneri Broun. T. xlv, 148.
sylvanus Broun. T. xlv, 149.
Dysnocryptus Broun, 1893.
plagiatus Broun. C. 1258.
testaceus Broun. C. 1259.
pallidus Broun. C. 1259.
maculifer Broun. C. 1260.
nigricans Broun. C. 1260.
inflatus Sharp. C. 562.
dignus Broun. C. 563.
rugosus Sharp. C. 563.
setigerus Broun. B. 1, vii, 658.
Araeocerus Pascoe, 1876.
pardalis Pascoe. C. 559.
Xenanthribus Broun, 1893.
hirsutus Broun. C. 1270.
Doticus.
**pestilens* Olliff.

Family CURCULIONIDAE.

Subfamily OTIORHYNCHINAE.

Nicaeana Pascoe, 1877.
modesta Pascoe. C. 428.
concinna Broun. C. 847.
cinerea Broun. C. 931.
cervina Broun. C. 1360.
tarsalis Broun. C. 1460.
infuscata Broun. A. 8, iv, 52.
catoptoides Broun. B. 1, iii, 200.
placida Broun. B. 1, iii, 201.
gracilicornis Broun. B. 1, iii, 201.
crassifrons Broun. B. 1, v, 398.
nesophila Broun. T. xlv, 97.
cordipennis Broun. B. 1, vii, 619.
Aphela.
pictipes Broun. A. 7, xii, 75.
Stygeopetes Broun, 1893.
littoralis Broun. C. 1176.
Thotmus Broun, 1910.
halli Broun. T. xliii, 103.
Cecyropa Pascoe, 1875.
tychioides Pascoe. C. 437.
maritima Broun. C. 438.
brevipennis Broun. C. 438.
alba Broun. C. 698.
varia Broun. C. 698.
discors Broun. C. 699, and A. 7, xiv, 106.

Cecyropa—continued.
setigera Broun. C. 905.
macularia Broun. C. 961.
albicans Sharp. C. 1175.
fumosa Broun. C. 1175.
alternata Broun. A. 7, xiv, 105.
lineifera Broun. A. 7, xii, 72.
striata Broun. A. 7, xii, 73.
sulcifrons Broun. B. 1, v, 398.
striatella Broun. B. 1, v, 399.
jucunda Broun. B. 1, v, 400.
laticollis Broun. B. 1, v, 400.
litorea Broun. B. 1, vi, 343.
Nonnotus Sharp, 1886.
griseolus Sharp. C. 1177.
eclectus Broun. C. 1177.
pallescens Broun. C. 1178.
albicans Broun. C. 443.
albatus Broun. C. 694.
nigricans Broun. T. xlv, 98.
Tigones Broun, 1886.
caudata Broun. C. 855.
osculans Broun. C. 856.
certa Broun. C. 856.
grisea Broun. C. 856.
cervina Broun. C. 857.
aulica Broun. C. 1180.
variegata Broun. C. 1181.
scutellaris Broun. C. 1181.
cruda Broun. C. 1182.
antennalis Broun. C. 1182.
diversa Broun. C. 1183.
rufula Broun. C. 1183.
cavelli Broun. C. 1361.
obscura Broun. C. 1361.
cuspidata Broun. C. 694.
plana Broun. C. 700.
dispar Broun. A. 7, xiv, 107.
philpotti Broun. B. 1, i, 57.
humeralis Broun. B. 1, iii, 202.
flectiscapus Broun. B. 1, iii, 202.
nasalis Broun. B. 1, v. 401.
citimus Broun. B. 1, v, 401.
thoracica Broun. B. 1, v, 402.
variata Broun. B. 1, v, 403.
murina Broun. B. 1, v, 403.
assimilis Broun. B. 1, v, 404.
setosa Broun. B. 1, v, 404.
longiceps Broun. B. 1, v, 405.
bicostellus Broun. B. 1, vi, 544.
albopicta Broun. T. xlv, 100.
gracilis Sharp. C. 1179.
binodulus Sharp. C. 1179.
robustus Sharp. C. 1180.
rugosa Broun. T. xlv, 99.
longipes Broun. B. 1, vii, 620.
Epitimetes Pascoe, 1877.
lutosus Pascoe. C. 435.
wakefieldi Sharp. C. 1183.
cupreus Broun. B. 1, v, 406.
foveiger Broun. B. 1, v, 406.
grisealis Broun. T. xlv. 97.
bicolor Broun. B. 1, vii, 621.
densus Broun. B. 1, vii, 622.

Group RHYNCHOPHORA—*continued.*

Exonastus Broun, 1919.
amplus Broun. B. 1, vii, 623.
fumidus Broun. B. 1, vii, 623.
Platyomida White, 1846.
binodes White. C. 442.
censoria Pascoe. C. 442.
aculeata Broun. C. 442.
perniciosa Broun. C. 442.
apicalis Broun. C. 701.
amota Broun. C. 793.
enysi Broun. C. 852.
aequa Broun. C. 932.
hochstetteri Redtenbacher. C. 476.
simulatrix Sharp. C. 1185.
depressa Broun. C. 1185.
brevicornis Broun. A. 7, xiv, 107.
caudata Broun. B. 1, i, 54.
humeralis Broun. B. 1, i, 55.
tibialis Broun. B. 1, i, 56.
verrucosa Broun. B. 1, ii, 120.
philpotti Broun. B. 1, vi, 545.
hamiltoni Broun. T. xlv, 100.
morosa Broun. T. xlv, 101.
dorsalis Broun. B. 1, v, 407.
cuprealis Broun. B. 1, v, 408.
fuscella Broun. B. 1, v, 409.
rectirostris Broun. B. 1, v, 409.
hystricula Broun. B. 1, v, 410.
sulcicollis Broun. B. 1, v, 410.
latipennis Broun. B. 1, v, 411.
versicolor Broun. T, xliii, 103.
Thesius Broun, 1909.
inophlaeoides. A. 8, iv, 60.
Rhynchogonus.
germanus Broun. A. 6, xii, 293.
Lyperobates Broun, 1893.
asper Broun. C. 1462.
guinnessi Broun. T. xlv, 101.
elegantulus Broun. T. xlv, 102.
rostralis Broun. T. xlv, 103.
punctatus Broun. T. xlv, 103.
waterworthi Broun. B. 1, i, 57.
carinifer Broun. B. 1, i, 58.
ardens Broun. B. 1, i, 59.
virilis Broun. A. 8, iv, 58.
Zenographus Broun, 1915.
metallescens Broun. B. 1, iv, 327.
allinotatus Broun. B. 1, vii, 625.
Hygrochus Broun, 1881.
oscitans Broun. C. 703.
verrucosus Broun. C. 1220.
illepidus Broun. C. 1220.
oculatus Broun. A. 6, xii, 292.
cordipennis Broun. B. 1, i, 59.
scutellaris Broun. B. 1, ii, 121.
granifer Broun. A. 8, iv, 58.
monilifer Broun. B. 1, vii, 625.
Homodus Broun, 1881.
fumeus Broun. C. 703.
posticalis Broun. B. 1, viii, 697.
longicornis Broun. B. 1, viii, 698.
cuprealis Broun. B. 1, viii, 698.
Aporolobus Sharp, 1886.
irritus Pascoe. C. 431 and C. 1186.
hariolus Broun. C. 848.
Aporolobus—continued.
cecyropioides Broun. C. 905.
rugosus Broun. C. 930.
pallidus Broun. C. 1365.
albosparsus Broun. B. 1, ii, 120.
scapalis Broun. B. 1, vi, 545.
Proboscocoelus Broun, 1909.
sculpturatus Broun. A. 8, iv, 56.
Notiopatae Broun, 1893.
setifer Broun. C. 1187.
sternalis Broun. C. 1462.
clarus Broun. C. 431.
terricola Broun. T. xlv, 105.
Phaeocharis Broun, 1913.
cuprealis Broun. T. xlv, 105.
punctatus Broun. T. xlv, 105.
Paelocharis Broun, 1893.
inflata Broun. C. 1188.
vestita Broun. C. 1463.
corpulenta Broun. C. 431.
Getopsephus Broun, 1913.
acuminatus Broun. T. xlv, 107.
costifer Broun. B. 1, vi, 558.
funestus Broun. B. 1, vi, 559.
Protolobus Sharp, 1886.
obscurus Sharp. C. 1188.
porculus Pascoe. C. 430.
granicollis Broun. B. 1, iii, 203.
nodosus Broun. B. 1, v, 412.
Drymaria Broun, 1909.
cilipes Broun. A. 8, iv, 57.
Heterexis Broun, 1909.
sculptipennis Broun. S, 114.
laevinsculus Broun. S. 114.
Calodryobius Broun, 1909.
vestitus Broun. S. 109.
benhami Broun. S. 110.
tetricus Broun. S. 110.
erubescens Broun. S. 111.
grandis Broun. S. 112.
Inocatoptes Broun, 1909.
incertus Broun. S. 113.
Catoptes Schönherr, 1842.
obliquis Schönherr. C. 428.
parilis Pascoe. C. 443.
compressus Broun. C. 429.
obliquisignatus Bohem. C. 693.
attenuatus Broun. C. 791.
pilosellus Broun. C. 853.
bicostatus Broun. C. 853.
vexator Broun. A. 7, xiv, 108.
egeus Broun. A. 7, xiv, 109.
duplex Broun. A. 7, xiv, 110.
spermophilus Broun. A.
aequalis Broun. A.
constrictus Broun. B. 1, i, 60.
tibialis Broun. C. 854.
stolidus Broun. C. 854.
caliginosus Broun. C. 1189.
posticalis Broun. C. 1189.
humeralis Broun. C. 1190.
chalmeri Broun. C. 1190.
asperellus Broun. C. 1191.
cheesemani Broun. C. 1191.
decorus Broun. C. 1192.

Group RHYNCHOPHORA—continued.

Catoptes—continued.
brevicornis Sharp. C. 1193.
aemulator Broun. C. 1193.
tenebricus Broun. C. 1194.
latipennis Broun. C. 1362.
furvus Broun. C. 1362.
vastator Broun. C. 1463.
scutellaris Sharp. C. 1503.
longulus Sharp. C. 1504.
limbatus Broun. A. 8, iv, 60.
spectabilis Broun. B. 1, iii, 205.
subnitidus Broun. B. 1, iii, 206.
curvatus Broun. B. 1, iii, 206.
carinalis Broun. B. 1, iii, 207.
argentalis Broun. B. 1, iii, 208.
fumosus Broun. B. 1, iii, 208.
subplicatus Broun. B. 1, v, 412.
dehiscens Broun. B. 1, v, 413.
robustus Broun. B. 1, v, 414.
albosparsus Broun. B. 1, v, 415.
pallidipes Broun. B. 1, v, 415.
flaviventris Broun. B. 1, v, 416.
nigricans Broun. B. 1, v, 416.
lobatus Broun. B. 1, vii, 626.
apicalis Broun. B. 1, viii, 691.
Haplolobus Broun, 1893.
saevus Broun. C. 1199.
aethiops Broun. C. 1199.
gregalis Broun. C. 1199.
frontalis Broun. B. 1, iii, 204.
granulatus Broun. B. 1, iii, 204.
Neoevas Broun, 1919.
celmisiae Broun. B. 1, vii, 624.
Heterodiscus Sharp, 1886.
insolitus Sharp. C. 1197.
Echinopeptus Broun, 1886.
dilatatus Broun. C. 852.
verrucatus Broun. B. 1, iii, 211.
dorsalis Broun. B. 1, iii, 212.
Brachyolus White, 1846.
punctatus White. C. 432.
breviusculus Broun. C. 440.
elegans Broun. C. 1194.
inaequalis Sharp. C. 1195.
huttoni Sharp. C. 1195.
bagooides Sharp. C. 1195.
punctipennis Sharp. C. 1196.
longicollis Sharp. C. 1196.
viridescens Broun. C. 1363.
posticalis Broun. C. 1364.
albescens Broun. A. 7, xii, 73.
cervalis Broun. A. 7, xii, 74.
sylvaticus Broun. B. 1, i, 61.
asperatus Broun. B. 1, iii, 209.
fuscipictus Broun. B. 1, iii, 210.
bicostatus Broun. B. 1, v, 416.
terricola Broun. B. 1, v, 417.
labeculatus Broun. T. xlv, 107.
varius Broun. T. xlv, 108.
nodirostris Broun. B. 1, vii, 627.
obscurus Broun. B. 1, vii, 628.
Bryodrassus Broun, 1917.
miricollis Broun. B. 1, v, 418.
Inocatoptes Broun, 1902.
incertus Broun. T. xxxiii, 178.

Agatholobus Broun, 1913.
waterhousei Broun. T, xlv, 109.
Inophloeus Pascoe, 1875.
traversii Pascoe. C. 439.
inuus Pascoe. C. 439.
rhesus Pascoe. C. 439.
vitiosus Pascoe. C. 440.
rubidus Broun. C. 699.
nigellus Broun. C. 700.
praelatus Broun. C. 851.
sulcifer Broun. C. 905.
costifer Broun. C. 932.
egregius Broun. C. 962.
nodifer Broun. C. 1200.
alacer Broun. C. 1200.
albonotatus Broun. C. 1201.
vestitus Broun. C. 1202.
suturalis Broun. C. 1464.
villaris Pascoe. A. 4, xvi, 220.
medius Broun. A. 6, xii, 294.
sternalis Broun. A. 7, xiv, 111.
discrepans Broun. A. 7, xiv, 112.
longicornis Broun. A. 7, xiv, 113.
quadricollis Broun. A. 8, iv, 53.
laetificus Broun. A. 8, iv, 54.
peusus Broun. B. 1, iii, 212.
sulcicollis Broun. B. 1, iii, 213.
aplorhinus Broun. B. 1, iv, 327.
tricostatus Broun. B. 1, iv, 328.
fuscatus Broun. B. 1, v, 419.
collinus Broun. B. 1, v, 419.
cuprellus Broun. B. 1, vii, 628.
obsoletus Broun. B. 1, vii, 629.
sexnodosus Broun. B. 1, vii, 630.
festucae Broun. B. 1, vii, 631.
Otiorhynchus Germar.
*sulcatus Fabricius.

Subfamily CYLINDRORHINAE.

Phaeophanus Broun, 1886.
rugosus Broun. C. 793.
similis Broun. C. 1216.
lituratus Broun. C. 1216.
o'connori Broun. B. 1, vii, 631.
inornatus Broun. B. 1, vii, 632.
Heteraomus Broun, 1893.
longipes Broun. C. 1218.
Anagotus Sharp, 1882.
helmsi Sharp. C. 1215.
pallesceus Broun. A. 7, xii, 76.
Mecosargon Broun, 1915.
costipennis Broun. B. 1, iv, 329.
Sargon Broun, 1903.
carinatus Broun. A. 7, xii, 77.
hudsoni Broun. A. 8, iv, 70.
Pparchus Broun, 1904.
lewisi Broun. A. 7, xiv, 114.
halli Broun. B. 1, iv, 330.
Phaedropholus Broun, 1910.
o'connori Broun. B. 1, i, 67.
Phoroteles Broun, 1893.
graniger Broun. C. 850.
Heterotyles Broun, 1886.
argentatus Broun. C. 795.

Group RHYNCHOPHORA—*continued.*

Rhadinosomus Schönherr, 1840.
  acuminatus Schönherr. C. 430.
Heteromias Broun, 1913.
  foveirostris Broun. T. xlv, 121.
Hadramphus Broun, 1910.
  spinipennis Broun. T. xliii, 105.

Subfamily MOLYTINAE.

Lyperobius Pascoe, 1876.
  huttoni Pascoe. C. 445.
  tuberculatus Pascoe. C. 445.
  carinatus Broun. C. 702.
  cupiendus Broun. C. 962.
  laeviusculus Broun. T. xxiii, 179.
  hudsoni Broun. B. 1, ii, 127.
  aciphyllae Broun. B. 1, v, 442.
  fallax Broun. B. 1, v, 443.
  spedenii Broun. B. 1, v, 443.
Liparogetus Broun, 1915.
  sulcatissimus Broun. B. 1, iv, 331.
Lyperopais Broun, 1893.
  mirus Broun. C. 1222.
  alternans Broun. B. 1, ii, 128.

Subfamily HYLOBIINAE.

Eiratus Pascoe, 1877.
  parvulus Pascoe. C. 447.
  tetricus Broun. C. 447.
  costatus Broun. C. 794.
  ornatus Broun. C. 906.
  suavis Broun. C. 934.
  pyriformis Broun. C. 1223.
  rugosus Broun. C. 1223.
  nitirostris Broun. B. 1, i, 65.
Bryocatus Broun, 1914.
  alternans Broun. B. 1, iii, 219.
  jugosus Broun. B. 1, iii, 219.
  nodicollis Broun. B. 1, iii, 220.
  nigrirostris Broun. B. 1, iii, 220.
  amplus Broun. B. 1, iii, 221.
  burrowsi Broun. B. 1, iv, 332.
  quadricollis Broun. B. 1, vi, 559.
  rubidus Broun. B. 1, vi, 559.
  elegans Broun. B. 1, vi, 560.
  humeratus Broun. B. 1, vi, 560.
  lugubris Broun. B. 1, vi, 561.
  crassirostris Broun. B. 1, vi, 561.
  niticollis Broun. B. 1, vii, 633.
  iridescens Broun. B. 1, vii, 633.
  rugosus Broun. B. 1, vii, 634.
  plicatus Broun. B. 1, viii, 693.
  crassipes Broun. B. 1, viii, 694.
  angustus Broun. B. 1, viii, 694.
  fordi Broun. B. 1, viii, 694.
  diversus Broun. B. 1, viii, 695
  thoracicus Broun. B. 1, viii, 695.
  ovipennis Broun. B. 1, viii, 696.
Stilboderma Broun, 1909.
  impressipennis Broun. A. 8, iv, 68.
Exeiratus Broun, 1914.
  setarius Broun. B. 1, ii, 129.
Athor Broun, 1909.
  arcifera Broun. A. 8, iv, 69.

Dryopais Broun, 1886.
  variabilis Broun. C. 933.
Paedaretus Pascoe, 1876.
  hispidus Pascoe. C. 444.
  rufulus Broun. B. 1, i, 65.

Subfamily RHYPAROSOMINAE.

Phrynixus Pascoe, 1875.
  terreus Pascoe. C. 433.
  astutus Pascoe. C. 433.
  celatus Broun. C. 433.
  modicus Broun. C. 434.
  facetus Broun. C. 695.
  intricatus Broun. C. 848.
  tuberculatus Broun. C. 849.
  differens Broun. C. 849.
  rufipes Broun. C. 849.
  simplex Broun. C. 1202.
  costirostris Broun. C. 1203.
  humeralis Broun. C. 1467.
  brevipennis Broun. C. 1468.
  cedius Broun. C. 1468.
  longulus Broun. B. 1, i, 61.
  rufiventris Broun. B. 1, ii, 121.
  bicarinellus Broun. A. 8, iv, 61.
  ventralis Broun. A. 8, iv, 62.
  squamalis Broun. B. 1, vi, 546.
  humilis Broun. B. 1, vi, 547.
  amoenus Broun. B. 1, vi, 547.
  setipes Broun. T. xlv, 110.
  binodosus Broun. T. xlv, 111.
  asper Broun. T. xliii, 104.
  conspicuus Broun. B. 1, vii, 634.
  blandus Broun. B. 1, vii, 635.
Bradypatae Broun, 1893.
  capitalis Broun. C. 1206 and 850.
  armiger Broun. A. 6, xii, 296.
  dilaticollis Broun. A. 8, iv, 66.
  interstitialis Broun. A. 8, iv, 67.
  minor Broun. T. xlv, 112.
  subnodifer Broun. B. 1, vii, 636.
  impressum Broun. B. 1, vii, 637.
Erymneus Pascoe, 1877.
  sharpi Pascoe. C. 436.
  scabiosus Broun. C. 436.
  castaneus Broun. C. 436.
  granulatus Broun. C. 437.
  longulus Broun. C. 931.
  coenosus Broun. C. 932.
  ferrugatus Broun. C. 1203.
  irregularis Broun. C. 1367.
  crassipes Broun. C. 1469.
  firmus Broun. C. 1470.
  probus Broun. A. 6, xii, 299.
  terrestris Broun. B. 1, vi, 548.
Lithocia Broun, 1893.
  fimbriata Broun. C. 1471.
  angustula Broun. B. 1, iii, 214.
  ciligera Broun. B. 1, v, 420.
  setirostris Broun. B. 1, v, 421.
  basalis Broun. B. 1, v, 421.
  rectisetosa Broun. B. 1, v, 422.
  nigricrista Broun. B. 1, v, 423.
  acuminata Broun. T. xlv, 111.
  stictica Broun. B. 1, viii, 692.

Group RHYNCHOPHORA—*continued.*

Abrotheus Broun, 1917.
placitus Broun. B. 1, v, 424.
Pachyprypnus Broun, 1886.
pyriformis Broun. C. 792.
longiusculus Broun. C. 434.
modicus Broun. A. 7, xiv, 117.
Dolioceuthus Broun, 1893.
dumetosus Broun. C. 1208.
vestitus Broun. C. 1209.
Astyplus Broun, 1893.
conicus Broun. C. 1210.
brevicornis Broun. B. 1, vii, 640.
Styphlotelus Broun, 1893.
foveatus Broun. C. 1368.
fascicularis Broun. C. 1369.
Halliella Broun, 1917.
squamipes Broun. B. 1, v, 425.
antennalis Broun. B. 1, v, 425.
longicollis Broun. B. 1, v, 426.
cuneata Broun. B. 1, vii, 640.
Allostyphlus Broun, 1919.
jugosus Broun. B. 1, vi, 549.
Phrynixodes Broun, 1919.
scruposus Broun. B. 1, vi, 551.
Cuneopterus Sharp, 1886.
conicus Sharp. C. 1204.
tenuicornis Broun. A. 6, xii, 297.
Chamaepsephis Broun, 1893.
aurisetifer Broun. C. 1207.
Amphiskirra Broun, 1909.
umbricola Broun. A. 8, iv, 64.
Araeoscapus Broun, 1893.
ovipennis Broun. A. 6, xii, 300.
flavipes Broun. C. 1473.
thoracicus Broun. C. 1474.
obscurus Broun. C. 1475.
fasciculatus Broun. B. 1, i, 62.
mucronatus Broun. B. 1, i, 63.
punctipennis Broun. B. 1, i, 64.
brevicollis Broun. B. 1, ii, 125.
ardens Broun. A. 8, iv, 64.
estriatus Broun. A. 8, iv, 65.
ocularius Broun. B. 1, iii, 215.
subcostatus Broun. B. 1, vii, 637.
Memes Broun. 1903.
rufirostris Broun. A. 7, xii, 79.
Baeosomus Broun, 1904.
tacitus Broun. A. 7, xiv, 119.
Bantiades Broun, 1893.
fuscatus Broun. C. 1371.
valgus Broun. C. 1472.
suturalis Broun. B. 1, ii, 123.
nodosus Broun. B. 1, ii, 125.
cupiendus Broun. B. 1, iii, 215.
morosus Broun. B. 1, v, 426.
cylindricus Broun. B. 1, v, 427.
notatus Broun. B. 1, v, 428.
rectalis Broun. B. 1, vi, 551.
trifoveatus Broun. B. 1, vi, 552.
Abantiades Broun, 1914.
nodipennis Broun. B. 1, iii, 217.
pusillus Broun. B. 1, iii, 217.
gratulus Broun. B. 1, v, 428.
Rachidiscus Broun, 1893.
granicollis Broun. C. 1478.
multinodosus Broun. T. xlv, 116.
Rachidiscodes Broun, 1917.
altipennis Broun. B. 1, v, 430.
glabrus Broun. B. 1, vi, 552.
Dermotrichus Sharp, 1886.
mundulus Broun. C. 1205.
multicristatus Broun. B. 1, v, 434.
elegantalis Broun. B. 1, v, 435.
vicinus Broun. B. 1, vii, 638.
curvirostris Broun. B. 1, vii, 639.
Allaorops Broun, 1917.
carinatus Broun. B. 1, v, 430.
Hycanus Broun, 1905.
cockaynei Broun. A. 7, xv, 546, and S. 116.
frontalis Broun. S. 116.
Stilbodiscus Broun, 1909.
setarius Broun. S. 118.
Clypeorhynchus Sharp, 1883.
gracilipes Sharp. C. 1211.
thoracicus Broun. C. 1211.
brevicornis Broun. C. 1212.
impressus Broun. C. 1212.
ovipennis Broun. C. 1213.
cordipennis Broun. C. 1370.
cristatus Broun. C. 1370.
inophloeoides Broun. A. 7, xiv, 117.
nodiceps Broun. B. 1, iii, 218.
striatus Broun. B. 1, iv, 333.
clarulus Broun. B. 1, v, 431.
merus Broun. B. 1, v, 431.
setosus Broun. B. 1, v, 432.
nitidellus Broun. B. 1, v, 433.
halli Broun. B. 1, v, 433.
dorsalis Broun. B. 1, vi, 553.
bicarinatus Broun. B. 1, vi, 554.
calvulus Broun. T. xlv, 113.
caudatus Broun. T. xlv, 114.
tenuiculus Broun. B. 1, vii, 641.
furvus Broun. B. 1, vii, 642.
bifoveatus Broun. B. 1, viii, 692.
Phygothalpus Broun, 1915.
sulcicollis Broun. T. xlv, 118.
nitidulus Broun. B. 1, iv, 334.
majusculus Broun. B. 1, iv, 334.
philpotti Broun. B. 1, v, 435.
granissimus Broun. B. 1, v, 436.
sulcipennis Broun. B. 1, v, 437.
striatus Broun. B. 1, vi, 556.
anthracinus Broun. B. 1, vi, 557.
Dacnophylla Broun, 1893.
setosa Broun. C. 1472.
variegata Broun. A. 6, xii, 301.
sparsa Broun. B. 1, vi, 554.
Nestrius Broun, 1893.
serripes Broun. C. 1480, and A. 6, xii, 302.
crassicornis Broun. B. 1, iv, 335.
sulcirostris Broun. B. 1, v, 437.
prolixus Broun. B. 1, v, 438.
zenoscelis Broun. B. 1, vi, 555.
simmondsi Broun. B. 1, vi, 556.
Plotnus Broun, 1893.
ovithorax Broun. C. 1481.
Phemus Broun, 1893.
scabralis Broun. C. 1214.
rufipes Broun. C. 1482

Group RHYNCHOPHORA—*continued.*

Phemus—continued.
curvipes Broun. T. xlv, 114.
constrictus Broun. T. xlv, 115.
Rystheus Broun, 1893.
ocularius Broun. C. 1219.
notabilis Broun. B. 1, v, 441.
Mososgenes Broun, 1917.
longiventris Broun. B. 1, v, 439.
acerbus Broun. B. 1, vii, 643.
Sosgenes Broun, 1893.
carinatus Broun. C. 1477.
longicollis Broun. B. 1, ii, 122.
discalis Broun. B. 1, v, 440.
planirostris Broun. T. xlv, 116.
Phyllodytes Broun, 1893.
foveatus Broun. C. 1479.
irregularis Broun. B. 1, i, 64.
Phronira Broun, 1893.
sulcirostre Broun. C. 696.
asper Broun. C. 696.
costosum Broun. C. 696.
osculans Broun. C. 697.
simplex Broun. C. 697.
striatum Broun. C. 697.
nodosum Broun. C. 1476.

Subfamily AMYCTERINAE.

Tocris Broun, 1904.
latirostris Broun. A. 7, xiv, 160.
laevicostata Broun. B. 1, ii, 126.
hamiltoni Broun. T. xlv, 119.
pascoi Broun. B. 1, v, 442.
aterrima Broun. T. xlv, 118.

Subfamily ERIRHININAE.

Philacta Broun, 1880.
testacea Broun. C. 449.
maculifera Broun. A. 7, xiv, 119.
Erirhinus Schönherr, 1826.
acalyptoides Pascoe. C. 450.
limbatus Pascoe. C. 450.
glottis Pascoe. C. 450.
fusconotatus Broun. C. 451.
discoideus Broun. C. 451.
flavitarsis Broun. C. 451.
fasciatus Broun. C. 452.
rubricalis Broun. C. 452.
viridipennis Broun. C. 452.
sexmaculatus Broun. C. 706.
dolosus Broun. C. 707.
fascialis Broun. C. 707.
crucigerus Broun. C. 708.
anchoralis Broun. C. 708.
gracilirostris Broun. C. 708.
stramineus Broun. C. 709.
subconicollis Broun. B. 1, viii, 699.
nocens Broun. C. 709.
acceptus Broun. C. 710.
titahensis Broun. T. xlv, 122.
poecilus Broun. B. 1, viii, 700.
femoralis Broun. C. 710.
concolor Broun. C. 710.
eustictus Broun. C. 857.
veronicae Broun. C. 858.

Erirhinus—continued.
thomsoni Broun. C. 858.
bicavus Broun. C. 859.
melastomus Broun. C. 859.
confusus Broun. C. 860.
xenorhinus Broun. C. 860.
durus Broun. C. 861.
fuscoventris Broun. C. 861.
fulvus Broun. C. 862.
cheesemani Broun. C. 963.
difformipes Broun. C. 964.
nesobius Broun. C. 965.
anxius Broun. C. 1372.
fuscipes Broun. C. 1373.
pectoralis Broun. B. 1, ii, 131.
insignis Broun. A. 8, iv, 130.
insolitus Broun. A. 8, iv, 131.
spadiceus Broun. A. 8, iv, 132.
castigatus Broun. A. 8, iv, 132.
sylvaticus Broun. B. 1, iii, 225.
cordipennis Broun. B. 1, iv, 336.
celmisiae Broun. B. 1, v, 444.
dilucidus Broun. B. 1, vi, 562.
altivagans Broun. B. 1, vi, 562.
leucocomus Broun. B. 1, vi, 563.
oleariae Broun. T. xlv, 122.
exilis Broun. T. xlv, 123.
dracophyllae Broun. S. 118.
obscurus Broun. B. 1, viii, 699.
Anthonomus, Germar.
**pomorum*, Linnaeus.
Dorytomus Stephens, 1831.
trilobus Pascoe. C. 453.
rufirostris Broun. C. 453.
lateralis Broun. C. 711.
sudus Broun. C. 711.
ochraceus Broun. C. 712.
aericomus Broun. C. 795.
aciphyllae Broun. C. 965.
grossus Broun. C. 1224.
fulvescens Broun. B. 1, iii, 225.
melastictus Broun. B. 1, iii, 226.
albisetosus Broun. B. 1, iii, 227.
terrestris Broun. B. 1, iii, 227.
floricola Broun. B. 1, iii, 228.
methvenensis Broun. B. 1, iv, 336.
vittatus Broun. B. 1, vi, 563.
maorinus Broun. T. xlv, 123.
consonus Broun. T. xlv, 124.
australis Broun. B. 1, vii, 644.
Neomycta Pascoe, 1877.
pulicaris Pascoe. C. 457.
rubida Broun. C. 457.
seticeps Broun. B. 1, iii, 229.
Euprocas Broun, 1886.
scitulus Broun. C. 1375.
Alloprocas Broun, 1886.
rufus Broun. C. 1374.
niger Broun. C. 1374.
muticus Broun. B. 1, iii, 229.
Xerostygnus Broun, 1903.
binodulus Broun. A. 7, xii, 80.
pullus Broun. B. 1, i, 68.
Celetotelus Broun, 1886.
fulvus Broun. C. 1375.

Group RHYNCHOPHORA—*continued.*

Phorostichus Broun, 1882.
linearis Broun. C. 705.
Simachus Broun, 1886.
montanus Broun. C. 963.
cuneipennis Broun. B. 1, iii, 230.
placens Broun. B. 1, vii, 644.
Aganeuma Broun, 1886.
rufula Broun. C. 1484.
Stilbopsis Broun, 1886.
politus Broun. C. 1483.
Etheophanus Broun, 1886.
pinguis Broun. C. 1233.
striatus Broun. B. 1, i, 69.
punctiventris. B. 1, iii, 231.
optandus Broun. B. 1, viii, 701.
nitidellus Broun. B. 1, viii. 701,
obscurus Broun. B. 1, viii, 702.
Praolepra Pascoe, 1880.
squamosa Pascoe. C. 454.
infusca Broun. C. 452.
albopicta Broun. C. 712.
rufescens Broun. C. 713.
varia Broun. C. 713.
asperirostris Broun. C. 713.
pallida Broun. C. 714.
fultoni Broun. C. 908.
Megacolabus Broun, 1886.
sculpturatus Broun. C. 1378.
Aneuma Pascoe, 1876.
fulvipes Pascoe. C. 455.
rubricalis Broun. C. 452.
stramineipes Broun. C. 862.
ferruginea Broun. C. 862.
compta Broun. C. 934.
erubescens Broun. B. 1, i, 68.
rufa Broun. B. 1, vi, 564.
oblonga Broun. B. 1, vi, 565.
rostralis Broun. B. 1, vi, 565.
conspersa Broun. B. 1, vi, 566.
spinifera Broun. T. xlv, 124.
Tysius Pascoe, 1875.
amplipennis Pascoe. C. 458.
purus Broun. C. 1224.
Cyttalia Pascoe, 1873.
dispar Broun. C. 907.
Caenophanus Broun, 1886.
flavipilus Broun. C. 796.
carbonarius Broun. B. 1, vii, 645.
Colabotelus Broun, 1914.
dealbatus Broun. B. 1, iii, 232.
Hypotagea Pascoe, 1876.
rubida Pascoe. C. 456.
testaceipennis Broun. C. 456.
variegata Broun. C. 456.
creperus Broun. C. 706.
simulans Broun. C. 706.
castanea Broun. C. 714.
vestita Broun. C. 715.
dissona Broun. C. 863.
tibialis Broun. C. 1376, and B. 1, vi, 567.
lewisi Broun. T. xlv, 131.
Eugnomus Schönherr, 1847.
elegans Pascoe. C. 458.
picipennis Pascoe. C. 459.

Eugnomus—continued.
fervidus Pascoe. C. 459.
wakefieldi Pascoe. C. 459.
fucosus Pascoe. C. 459.
interstitialis Broun. C. 460.
discolor Broun. C. 460.
cinnamoneus White. C. 461.
maculosus Broun. C. 715.
nubilans Broun. C. 715.
fasciatus Broun. C. 716.
luctuosus Broun. C. 863.
monachus Broun. C. 966.
argutus Sharp. C. 1225.
nobilis Broun. C. 1225.
aenescens Broun. C. 1226.
cyaneus Broun. C. 1227.
tarsalis Broun. C. 1227.
lituratus Broun. C. 1227.
aspersus Broun. C. 1376.
dennanensis Broun. T. xlv, 125.
spuamifer Broun. C. 1377.
maurus Broun. C. 1377.
antennalis Broun. A. 8, iv, 133.
femoralis Broun. A. 8, iv, 134.
albisetosus Broun. B. 1, vii, 645.
bryobius Broun. B. 1, v, 445.
alternans Broun. B. 1, v, 445.
tristis Broun. B. 1, v, 446.
atratus Broun. B. 1, vi, 566.
calvulus Broun. T. xlv, 125.
Oreocharis Broun, 1886.
nigriceps Broun. C. 864.
picigularis Broun. C. 865.
nigrescens Broun. C. 865.
cyanea Broun. C. 716.
vittata Broun. C. 1228.
dealbata Broun. C. 1228.
ferruginea Broun. A. 7, xiv, 120.
pullata Broun. A. 7, xiv, 121.
carinulata Broun. B. 1, iii, 233.
latipennis Broun. B. 1, iii. 234.
lineirostris Broun. B. 1, iii, 234.
pleuralis Broun. B. 1, iv, 337.
fasciata Broun. B. 1, v, 447.
congruens Broun. B. 1, v, 447.
albosparsa Broun. T. xlv, 126.
veronicae Broun. T. xlv, 127.
picipennis var. Broun. T. xlv, 127.
uniformis Broun. T. xlv, 127.
dives Broun. T. xlv, 128.
castanea Broun. T. xlv, 128.
Hoplocneme White, 1846.
hookeri White. C. 461.
punctatissima Pascoe. C. 461.
spuamosa Broun. C. 462.
inaequalis Broun. C. 1229.
cyanea Broun. C. 1230.
propinqua Broun. B. 1, iii, 233.
vicina Broun. T. xlv, 129.
Stephanorhynchus White, 1846.
curvipes White. C. 462.
purus Pascoe. C. 463.
brevipennis Pascoe. C. 463.
lawsoni Sharp. C. 463.
crassus Broun. C. 464.

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Stephanorhynchus—continued.
tuberosus Broun. C. 717.
fatuus Broun. C. 718.
griseipictus Broun. C. 866.
nigrosparsus Broun. C. 1230.
insolitus Broun. C. 1231.
costifer Broun. C. 1231.
attelaboides Fabricius. *Ent. Syst.*, 156.
pygmaeus Broun. A. 7, xii, 80.
osculator Broun. A. 8, iv, 134.
morosus Broun. A. 8, iv, 135.
halli Broun. B. 1, iii, 235.
Stenopactola Broun, 1914.
prolixa Broun. B. 1, iii, 237.
Pactola Pascoe, 1876.
variabilis Pascoe. C. 465.
demissa Pascoe. C. 465.
humeralis Broun. A. 6, xv, 407.
nitidula Broun. T. xlv, 129.
fuscicornis Broun. T. xlv, 130.
binodiceps Broun. T. xlv, 130.
Pactolotypus Broun, 1909.
striatus Broun. S. 119.
Brexius Pascoe, 1870.
ascitus Pascoe. C. 465.

Subfamily Apioninae.

Apion Herbst, 1797.
metrosideros Broun. C. 466.
terricola Broun. B. 1, viii, 702.

Subfamily Rhinomacerinae.

Rhinorhynchus Sharp, 1882.
rufulus Broun. C. 467.

Subfamily Belinae.

Pachyura Hope, 1833.
metallica Pascoe. C. 469.
rubicunda Broun. C. 469.
sumptuosa Broun. C. 470.
albocoma Broun. C. 1233.
stictica Broun. C. 1379.
venusta Broun. A. 8, iv, 136.
violacea Broun. A. 8, iv, 137.
aenescens Broun. B. 1, iv, 338.
brookesi Broun. B. 1, vi, 567.
Agathinus Broun, 1880.
tridens Fabricius. C. 471.

Subfamily Scolopterinae.

Scolopterus White, 1846.
tetracanthus White. C. 472.
aequus Broun. C. 473.
penicillatus White. C. 473.
pectoralis Broun. C. 474.
aeneorufus Broun. C. 718.
Icmalius Broun, 1893.
abnormis Broun. C. 908.
helmsi Sharp. *Ent. Mon. Mag.*, xviii, 47.
Nyxetes Pascoe, 1870.
bidens Fabricius. C. 474.
rufipes Broun. C. 718.

Ancistropterus White, 1846.
quadrispinosus White. C. 475.
brouni Sharp. C. 475.
pilosus Broun. C. 476.
Gonoropterus Broun, 1904.
spinicollis Broun. A. 7, xiv, 122.
Amylopterus Broun, 1886.
prasinus Broun. C. 797.
Oropterus White, 1846.
coniger White. C. 477.

Subfamily Tychiinae.

Sibinia Germar, 1824.
tychioides Pascoe. C. 478.

Subfamily Haplonychinae.

Geochus Broun, 1882.
inaequalis Broun. C. 446.
politus Broun. C. 704.
rugulosus Broun. C. 931.
similis Broun. C. 1221.
nodosus Broun. C. 1221.
plagiatus Broun. C. 1365.
puncticollis Broun. C. 1367.
squamosus Broun. C. 1465.
tibialis Broun. C. 1465.
marginatus Broun. C. 1466.
frontalis Broun. C. 1466.
nigripes Broun. C. 1467.
setiger Broun. A. 6, xii, 295.
sulcatus Broun. B. 1, ii, 129.
morosus Broun. B. 1, ii, 130.
pyriformis Broun. B. 1, iii, 221.
suffusus Broun. B. 1, iii, 222.
variegatus Broun. B. 1, iii, 223.
distinguens Broun. B. 1, iii, 223.
lateralis Broun. B. 1, iii, 224.
pictulus Broun. B. 1, vi, 568.
apicalis Broun. B. 1, vi, 569.
certus Broun. B. 1, vi, 570.
convexus Broun. B. 1, vi, 570.
posticalis Broun. T. xlv, 121.
rufipictus Broun. B. 1, viii, 696.

Subfamily Cryptorhynchinae.

Psepholax White, 1846.
sulcatus White. C. 479.
granulatus Broun. C. 479.
cornutus Broun. C. 479.
barbifrons White. C. 480.
punctulatus Broun. C. 480.
rostralis Broun. C. 480.
coronatus White. C. 481.
femoratus Broun. C. 481.
simplex Pascoe. C. 481.
mystacinus Broun. C. 866.
mediocris Broun. C. 909.
brevicornis Broun. C. 1382.
crassicornis Broun. A. 6, xv, 408.
denticostatus Broun. A. 8, iv, 139.
acanthomerus Broun. T. xlv, 132.

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Aphocoelis Broun, 1909.
versicolor Broun. A. 8, iv, 138.
Pseudoreda Broun, 1893.
tibialis Broun. C. 1383 and 482.
Oreda White, 1846.
notata White. C. 487.
brevis Pascoe. C. 487.
Kentraulax Broun, 1909.
murina Broun. C. 487.
flavisetosus Broun. T. xliii, 106.
Mesoreda Broun, 1893.
setigera Broun. C. 1235 and 488.
orthorhina Broun. C. 909.
sulcifrons Broun. A. 8, iv, 155.
longula Broun. T. xlv, 133.
laminata Broun. B. 1, vii, 646.
Homoreda Broun, 1893.
punctata Broun. C. 1383.
Aldonus White, 1846.
hylobioides White. C. 483.
celator Pascoe. C. 483.
rostratus Broun. C. 483.
chathamensis Sharp. T. xli, 149.
misturatus Broun. T. xlii, 309.
lineifer Broun. T. xlii, 310.
Nothaldonus Broun, 1893.
peacei Broun. C. 484.
Indecentia Broun, 1880.
nubila Broun. C. 485.
straminea Broun. C. 486.
Ectopsis Broun, 1881.
ferrugalis Broun. C. 719.
simplex Broun. A. 6, xii, 383.
foveigerus Broun. B. 1, v, 448.
Tychanus Pascoe, 1876.
gibbus Pascoe. C. 498.
ferrugatus Pascoe. C. 498.
densus Broun. C. 499.
verrucosus Pascoe. C. 499.
lachrymosus Broun. C. 729.
scabiosus Broun. C. 801.
quadratus Broun. C. 867.
ventralis Broun. C. 935.
bufo Sharp. C. 1239.
dux Broun. C. 1240.
squamosus Broun. B. 1, iii, 239.
lunalis Broun. B. 1, v, 448.
obscurus Broun. B. 1, vi, 573.
costatus Broun. T. xlv, 137.
complexus Broun. B. 1, vii, 648.
simulans Broun. B. 1, vii, 648.
terricola Broun. B. 1, vii, 649.
Clypeolus Broun, 1909.
cineraceus Broun. A. 8, iv, 143.
Euacalles Broun, 1919.
cristatus Broun. B. 1, vii, 647.
Sympedius Pascoe, 1876.
testudo Pascoe. C. 500.
vexatus Pascoe. C. 500.
curtus Broun. C. 728.
lepidus Broun. C. 935.
rectirostris Broun. A. 8, iv, 149.
minor Broun. B. 1, vii, 651.
Crisius Pascoe, 1876.
binotatus Pascoe. C. 500.
variegatus Broun. C. 501.
scutellaris Broun. C. 501.
obesulus Sharp. C. 1241.
picicollis Broun. C. 1241.
signatus Broun. C. 1242.
ornatus Broun. C. 1242.
fasciculatus Broun. C. 1492.
dorsalis Broun. A. 7, xiv, 123.
latirostris Broun. B. 1, iii, 240.
posticalis Broun. B. 1, v, 450.
contiguus Broun. B. 1, vi, 574.
eximius Broun. B. 1, vi, 574.
humeralis Broun. T. xlv, 138.
semifuscus Broun. T. xlv, 139.
decorus Broun. T. xlv, 139.
dives Broun. B. 1, vii, 650.
longulus Broun. B. 1, vii, 650.
Agacalles Broun, 1886.
formosus Broun. C. 967.
Getacalles Broun, 1893.
rostralis Broun. C. 1380.
minor Broun. C. 1381.
humeratus Broun. C. 1381.
inaequalis Broun. C. 1493.
sparsus Broun. B. 1, ii, 135.
fasciatus Broun. B. 1, ii, 136.
favosus Broun. A. 8, iv, 157.
posticalis Broun. B. 1, iii, 241.
fulvicornis Broun. B. 1, iii, 242.
parvulus Broun. B. 1, iii, 242.
variellus Broun. B. 1, iii, 243.
oblongus Broun. B. 1, iii, 243.
baccatellus Broun. B. 1, v, 449.
foveiceps Broun. B. 1, v, 450.
substriatus Broun. T. xlv, 147.
eucoelius Broun. B. 1, vii, 652.
fulvisparsus Broun. B. 1, vii, 653.
grisealis Broun. B. 1, vii, 653.
Omoeacalles Broun, 1909.
perspicuus Broun. A. 8, iv, 151.
Tychanopais Broun, 1893.
pictulus Broun. C. 1380.
flavisparsus Broun. T. xlv, 140.
dealbatus Broun. B. 1, vii, 654.
Atylodes Broun, 1914.
foveiger Broun. B. 1, ii, 137.
asaphus Broun. B. 1, vi, 577.
Dendrostygnus Broun, 1895.
calcaratus Broun. A. 6, xv, 410.
Hadracalles Broun, 1893.
fuliginosus Broun. C. 1384.
Pachyderris Broun, 1909.
punctiventris Broun. S. 121.
Acalles Schönherr, 1826.
intutus Pascoe. C. 489.
erroneus Pascoe. C. 489.
hystriculus Pascoe. C. 489.
impexus Pascoe. C. 490.
perpusillus Pascoe. C. 490.
trinotatus Broun. C. 490.
pascoei Broun. C. 491.
signatus Broun. C. 491.

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Acalles—continued.
tortipes Broun. C. 492.
crisioides Broun. C. 492.
vividus Broun. C. 493.
certus Broun. C. 493.
scitus Broun. C. 494.
ovatellus Broun. C. 720.
laeviculus Broun. C. 721.
cristatus Broun. C. 721.
rudis Broun. C. 721.
dorsalis Broun. C. 722.
volens Broun. C. 722.
horridus Broun. C. 723.
rubricus Broun. C. 723.
spurcus Broun. C. 724.
mundus Broun. C. 724.
canescens Broun. C. 725.
arctus Broun. C. 725.
vafrus Broun. C. 725.
griseus Broun. C. 797.
diversus Broun. C. 798.
cingulatus Broun. C. 798.
latirostris Broun. C. 799.
decemcristatus Broun. C. 800.
huttoni Broun. C. 801.
setifer Broun. C. 867.
posticalis Broun. C. 868.
terricola Broun. C. 934.
floricola Broun. C. 966.
veratrus Broun. C. 1235.
maritimus Broun. C. 1236.
cryptobius Broun. C. 1236.
ingens Broun. C. 1236.
xanthostictus Broun. C. 1237.
adamsi Broun. C. 1237.
concinnus Broun. C. 1238.
australis Broun. C. 1239.
mimus Broun. C. 1385.
lepirhinus Broun. C. 1385.
sympesioides Broun. C. 1386.
dolosus Broun. C. 1484.
comptus Broun. C. 1486.
facilis Broun. C. 1486.
quietus Broun. C. 1487.
integer Broun. A. 6, xii, 374.
ruficollis Broun. A. 6, xii, 376.
porcatus Broun. A. 6. xii, 377.
puncticollis Broun. A. 6, xii, 378.
farinosus Broun. A. 6, xii, 378.
fougeri Hutton. T. xxx, 157.
fuscatus Broun. A. 7, xix, 60.
multisetosus Broun. A. 7, xix, 61.
flynni Broun. B. 1, ii, 131.
notoporhinus Broun. B. 1, ii, 132.
fuscidorsis Broun. A. 8, iv, 143.
igneus Broun. A. 8, iv, 144.
altus Broun. A. 8, iv, 145.
albistrigalis Broun. A. 8, iv, 146.
aterrimus Broun. A. 8, iv, 146.
praesetosus Broun. A. 8, iv, 147.
robustus Broun. A. 8, iv, 148.
flavisetosus Broun. A. 8, iv, 149.
confusus Broun. B. 1, iii, 237.
bicristiceps Broun. B. 1, iii, 238.
ignotus Broun. B. 1, iii, 239.
furvus Broun. B. 1, iv, 339.

Acalles—continued.
bicinctus Broun. B. 1, iv, 339.
sternalis Broun. B. 1, v, 452.
nodigerus Broun. B. 1, v, 452.
zenomorphus Broun. B. 1, v, 454.
dentigerus Broun. B. 1, v, 455.
humeralis Broun. B. 1, vi, 571.
anceps Broun. B. 1, vi, 572.
cilicollis Broun. B. 1, vi, 573.
conicollis Broun. T. xlv, 134.
eruensis Broun. T. xlv, 134.
peelensis Broun. T. xlv, 135.
consors Broun. T. xlv, 136.
gracilis Broun. T. xlv, 136.
contractus Broun. T. xlv, 137.
lineirostris Broun. T. xliii, 107.
subcarinatus Broun. T. xliii, 107.
piciventris Broun. S. 120.
brevipennis Broun. B. 1, vii, 655.
hopensis Broun. B. 1, vii, 655.
bicostatus Broun. B. 1, vii, 656.
binodes Broun. B. 1, vii, 651.
sticticus Broun. B. 1, vii, 658.
brookesi Broun. B. 1, viii, 703.
Torilus Broun, 1909.
griseicollis Broun. A. 8, iv, 152.
Hatasu Broun, 1909.
dorsale Broun. A. 8, iv, 141.
tuberosa Broun. B. 1, viii, 704.
Onias Broun, 1909.
latisulcatus Broun. A. 8, iv, 153.
sentus Broun. C. 799.
ornatus Broun. A. 8, iv, 154.
albicristus Broun. B. 1, iii, 244.
irregularis Broun. T. xlv, 145.
Allanalcis Broun, 1912.
aulacus Broun. C. 1489.
allostethus Broun. C. 1490.
incultus Broun. C. 1490.
formosus Broun. A. 6, xii, 375.
ignealis Broun. T. xlv, 142.
oculatus Broun. T. xlv, 142.
dilatatus Broun. T. xlv, 143.
laticollis Broun. B. 1, iii, 245.
variatus Broun. B. 1, vi, 575.
seticollis Broun. B. 1, vi, 575.
albipictus Broun. B. 1, vi, 576.
melastictus Broun. B. 1, vi, 576.
blanditus Broun. B. 1, vi, 577.
Acallopais Pascoe, 1877.
rudis Pascoe. C. 495.
sculpturatus Broun. C. 495.
Scelodolichus Broun, 1880.
celsus Broun. C. 496.
lineithorax Broun. C. 496.
setosus Broun. C. 726.
villosus Broun. C. 726.
denotans Broun. C. 726.
altulus Broun. C. 968.
juncobius Broun. C. 1239.
hilaris Broun. C. 1491.
politus Broun. A. 6, xv, 412.
squamosus Broun. A. 6, xv, 413.
flectipes Broun. B. 1, ii, 134.
decorus Broun. B. 1, viii, 703.
pyriformis Broun. B. 1, viii, 704.

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Zeacalles Broun, 1893.
flavescens Broun. A. 6, xii, 380.
varius Broun. A. 6, xii, 381.
alpestris Broun. C. 1488.
picatus Broun. C. 1488.
binodosus Broun. B. 1, i, 69.
lepidulus Broun. A. 8, iv, 140.
carinellus Broun. B. 1, iii, 245.
estriatus Broun. B. 1, iii, 246.
scaber Broun. B. 1, iv, 340.
sparsus Broun. B. 1, iv, 341.
speciosus Broun. B. 1, v, 452.
aeratus Broun. B. 1, vi, 578.
coarctalis Broun. B. 1, vi, 578.
finitimus Broun. B. 1, vi, 579.
bisulcatus Broun. B. 1, vi, 579.
scruposus Broun. B. 1, vi, 580.
latulus Broun. B. 1, vi, 581.
inornatus Broun. B. 1, vi, 581.
parvus Broun. B. 1, vi, 582.
cordipennis Broun. B. 1, vi, 582.
pictus Broun. T. xlv, 144.
femoralis Broun. T. xlv, 145.
Cyclacalles Broun, 1880.
setiger Broun. C. 497.
vestitus Broun. C. 497.
Xenacalles Broun, 1912.
triangulatus Broun. C. 800.
squamiventris Broun. T. xliii, 108.
simplex Broun. B. 1, ii, 133.
nodifer Broun. B. 1, ii, 134.
nigricans Broun. B. 1, v, 451.
Schylus Broun, 1895.
nigricollis Broun. A. 6, xv, 412.
Metacalles Broun, 1893.
aspersus Broun. A. 6, xii, 382.
rugicollis Broun. A. 6, vii, 383.
cordipennis Broun. C. 720.
latus Broun. C. 727.
crinitus Broun. C. 727.
exiguus Broun. C. 728.
picatus Broun. B. 1, ii, 135.
crinitus Broun. T. xlv, 143.
lanosus Broun. T. xlv, 144.
Dermothrius Broun, 1882.
sanguineus Broun. C. 730.
Euthyrhinus Schönherr, 1837.
squamiger White. C. 503.
Baeorhynchodes Broun, 1909.
cristatus Broun. A. 8, iv, 159.
Rhyncodes White, 1846.
ursus White. C. 502.
saundersi White. C. 503.
squameus Broun. C. 730.
atrus Broun. C. 802.
weberi Colenso. T. xiv, 281.
rubipunctatus Colenso. T. xiv, 282.
Mitrastethus Redtenbacher, 1868.
bituberculatus Fabricius. C. 504.
Paranomocerus Redtenbacher, 1868.
spiculus Redtenbacher. C. 505.
maurus Broun. C. 505.
Idotasia Pascoe, 1871.
egena Pascoe. C. 506.
Mecistostylus Lacordaire, 1866.
douei Lacordaire. *Gen. Col.* vii.
Sympiezoscelus Waterhouse, 1853.
spencei Waterhouse. E. 2, ii, 204.
Gonipterus.
**reticulatus* Boisduval.
Calandra Clairville.
**granaria* Linnaeus.
**oryzae* Linnaeus.
Oxyops.
**concreta* Pascoe.
Sitones.
**lineatus* Linnaeus.

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Pentarthrum Wollaston, 1854.
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amicum Broun. T. xli, 156.
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brevirostre Sharp. T. xli, 157.
ruficorne Broun. T. xli, 157.
philpotti Broun. T. xli, 157.
melanosternum Broun. T. xli, 157.
punctirostre Broun. T. xli, 157.
planicolle Broun. T. xli, 158.
subsericatum Wollaston. T. xli, 157.
assimilatum Broun. T. xli, 158.
reductum Broun. T. xli, 158.
brunneum Broun. T. xli, 158.
nubilum Broun. T. xli, 158.
brevicorne Broun. B. 1, iii, 246.
impressum Broun. T. xlv, 147.
tenebrosum Broun. T. xlv, 148.
dissimilum Broun. T. xliii, 109.
auripilum Broun. T. xliii, 109.
Touropsis Broun, 1908.
punctatus Broun. T. xli, 159.
Euophryum Broun, 1908.
rufum Broun. T. xli, 160.
asperellum Broun. T. xli, 160.
sculpturatum Broun. T. xli, 160.
punctatissimum Broun. T. xli, 160.
dubitans Broun. T. xli, 161.
confinum Broun. T. xli, 161.
antennale Broun. T. xli, 161.
crassellum Broun. T. xli, 161.
servulum Broun. T. xli, 161.
porcatum Sharp. T. xli, 161.
Zenoteratus Broun, 1908.
macrocephalus Broun. T. xli, 162.
diversus Broun. T. xli, 162.
cephalotes Sharp. T. xli, 162.
Torostomo Broun, 1908.
apicale Broun. T. xli, 163.
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longirostre Wollaston. T. xli, 164.

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morosa Broun. T. xli, 165.
Merisma Broun, 1908.
sharpiana Wollaston. T. xli, 165.
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angusta Broun. T. xli, 167.
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aciphyllae Broun. B. 1, iii, 248.
Stenotoura Broun, 1908.
exilis Broun. T. xli, 167.
lateritia Broun. T. xli, 168.
prolixa Broun. T. xli, 168.
Eutassa Broun, 1908.
comatum Broun. T. xli, 169.
fuscicollis Broun. T. xli, 169.
Adel Broun, 1908.
crenatus Broun. T. xli, 170.
Rhinanisus Broun, 1886.
fulvicornis Broun. T. xli, 171.
parvicornis Sharp. T. xli, 171.
contiguus Broun. T. xli, 172.
sagax Broun. T. xli, 172.
cheesemani Broun. T. xli, 172.
lewisi Broun. T. xli, 172.
elongatus Broun. T. xli, 172.
subconvexus Broun. T. xli, 172.
suturalis Broun. T. xli, 172.
confertus Sharp. T. xli, 173.
constrictus Sharp. T. xli, 173.
sulcirostris Broun. T. xli, 173.
halli Broun. B. 1, iii, 248.
fusiformis Broun. B. 1, iii, 249.
Camptoscapus Broun, 1893.
sanguineus Broun. T. xli, 174.
planiusculus Broun. T. xli, 174.
conicollis Broun. T. xli, 174.
Macroscytalus Broun, 1886.
laticollis Broun. T. xli, 175.
depressus Broun. T. xli, 175.
russulus Broun. T. xli, 176.
remotus Sharp. T. xli, 176.
frontalis Broun. T. xli, 176.
badius Broun. T. xli, 176.
crenatus Broun. T. xli, 176.
Brorhopalus Broun, 1886.
glabrus Broun. T. xli, 177.
Selocomis Broun, 1908.
aeneopiceus Broun. T. xli, 178.
Glyphoramphus Broun, 1886.
rarus Broun. T. xli, 179.
Belka Broun, 1908.
spadicea Broun. T. xli, 180.
Attarus Broun, 1908.
tristis Broun. T. xli, 181.
castus Broun. T. xli, 181.
vestitus Broun. T. xli, 181.
Agastegnus Broun, 1886.
ruficollis Broun. T. xli, 182.
gratus Broun. T. xli, 183.
longipes Broun. T. xli, 183.
simulans Sharp. T. xli, 183.

Agastegnus—continued.
coloratus Broun. T. xli, 183.
femoralis Broun. T. xli, 183.
nitidirostris Broun. T. xli, 183.
distinctus Broun. T. xli, 183.
sericatus Broun. T. xli, 184.
rufescens Broun. T. xli, 184.
biimpressus Broun. T. xli, 184.
concinnus Broun. B. 1, iii, 251.
thoracicus Broun. B. 1, iii, 251.
rugipennis Broun. B. 1, iii, 252.
ornatus Broun. T. xliii, 110.
Sericotrogus Wollaston, 1873.
suboenescens Wollaston. T. xli, 185.
ovicollis Broun. T. xli, 185.
stramineus Broun. T. xli, 185.
plexus Broun. B. 1, iii, 250.
Gaurocyphus Broun, 1908.
auricomus Broun. T. xli, 186.
mirandus Broun. B. 1, iii, 253.
Eucossonus Broun, 1886.
comptus Broun. T. xli, 187.
elegans Broun. T. xli, 187.
gracilis Broun. T. xli, 187.
setiger Sharp. T. xli, 188.
rostralis Broun. T. xli, 188.
antennalis Broun. B. 1, i, 70.
discalis Broun. B. 1, i, 71.
constrictus Broun. B. 1, vi, 583.
sulcicollis Broun. B. 1, vi, 583.
nasalis Broun. B. 1, vi, 584.
disparilis Broun. B. 1, vi, 584.
oreobius Broun. B. 1, vi, 585.
Agrilochilus Broun, 1880.
prolixus Broun. T. xli, 189.
Dioedimorpha Broun, 1886.
wollastonianum Sharp. T. xli, 189.
debile Sharp. T. xli, 190.
Arecocryptus Broun, 1903.
bellus Broun. T. xli, 190.
Entium Sharp, 1878.
aberrans Sharp. T. xli, 191.
Mesoxenophasis Wollaston, 1874.
brouni Wollaston. T. xli, 192.
Proconus Broun, 1886.
asperirostris Broun. T. xli, 192.
crassipes Broun. T. xli, 192.
Heteropsis Wollaston, 1873.
lawsoni Wollaston. T. xli, 193.
Novitas Broun, 1880.
rufum Broun. T. xli, 194.
nigrans Broun. T. xli, 194.
dispar Broun. T. xli, 194.
Unas Broun, 1908.
piceus Broun. T. xli, 195.
Trachyglyphus Broun, 1908.
rugirostris Broun. T. xli, 196.
Microtribus Wollaston, 1873.
huttoni Wollaston. T, xli, 197.
pictonensis Sharp. T. xli, 197.
Idus Broun, 1893.
caecus Broun. T. xli, 198.
Protogonum Broun, 1908.
helmsianum Sharp. T. xli, 199.

Group RHYNCHOPHORA—*continued.*

COSSONIDES.

Phloeophagosoma Wollaston, 1873.
corvinum Wollaston. T. xli, 200.
thoracicum Wollaston. T. xli, 200.
dilutum Wollaston. T. xli, 200.
pedatum Wollaston. T. xli, 200.
rugipenne Broun. T. xli, 200.
abdominale Broun. T. xli, 201.

Eutornus Wollaston, 1873.
dubius Wollaston. T. xli, 202.
vicinus Broun. T. xli, 202.
breviceps Broun. T. xli, 202.
amplus Broun. T. xli, 203.
littoralis Broun. T. xli, 203.
cylindricus Broun. T. xli, 203.
parvulus Broun. T. xli, 203.

Stilbocara Broun, 1893.
nitida Broun. T. xli, 204.
constricticollis Broun. T. xli, 204.
serena Broun. T. xli, 204.

Arecophaga Broun, 1880.
varia Broun. T. xli, 205.

Pogonorhinus Broun, 1903.
opacus Broun. T. xli, 207.

Exomesites Broun, 1886.
optimus Broun. T. xli, 208.

Allaorus Broun, 1893.
urquharti Broun. T. xli, 209.
pedatus Broun. T. xli, 209.
sternalis Broun. T. xli, 209.
ovatus Broun. T. xli, 209.
versutus Broun. T. xli, 210.
rugosus Broun. T. xli, 210.
pyriformis Broun. T. xli, 210.
piciclavus Broun. T. xli, 210.
scutellaris Broun. B. 1, ii, 138.
impressus Broun. B. 1, v, 455.
carinifer Broun. B. 1, vi, 586.

Pselactus Broun, 1886.
punctatus Broun. T. xli, 212.
ferrugineus Broun. T. xli, 212.

Inosomus Broun, 1903.
rufopiceus Broun. T. xli, 213.

Xenocnema Wollaston, 1873.
spinipes Wollaston. T. xli, 214.

Hectoeus Broun, 1904.
rubidus Broun. T. xli, 215.

Family SCOLYTIDAE.

Subfamily SCOLYTINAE.

Pachycotes Sharp, 1877.
ventralis Sharp. C. 538.

Hylastes Erichson, 1836.
peregrinus Chapuis. C. 539.

Acrantus Broun, 1903 (substituted for *Homarus*, 1881).
mundulus Broun. C. 740.
opacus Broun. A. 6, xv, 417.

Dendrotrupes Broun, 1881.
vestitus Broun. C. 741.
costiceps Broun. C. 741.

Tomicus Latreille, 1810.
asper Broun. C. 742.

Mesoscolytus Broun, 1903 (substituted for *Apate*).
inurbanus Broun. C. 346, and A. 7, xiv, 126.

Subfamily PLATYPIDAE.

Platypus Herbst, 1793.
douei Reich. C. 540.
apicalis White. C. 541.
caviceps Broun. C. 541.
castaneus Broun. C. 542.
lobatus Broun. C. 1253.
gracilis Broun. C. 1254.
inimicus Broun. B. 1, i, 71.

Family AGLYCYDERIDAE.

Aglycyderes Westwood.
wollastoni Sharp. C. 426.
badius Broun. C. 427.

Art. 29.—*Notes on the Mating-habits and Early Life-history of the Culicid* Opifex fuscus *Hutton.*

By H. B. Kirk, M.A., F.N.Z.Inst., Professor of Biology, Victoria University College, Wellington.

[*Read before the Wellington Philosophical Society, 26th October, 1921; received by Editor, 31st December, 1921; issued separately, 30th April, 1923.*]

This particularly interesting mosquito has long been known to observers, and was generally supposed to be undescribed until, in the early part of this year, Mr. David Miller published some notes with regard to certain of its structural peculiarities, when Mr. G. V. Hudson called attention to the fact that Hutton had described it in 1902 (*Trans. N.Z. Inst.*, vol. 34, p. 188), placing it among the Tipulids. It is never found away from the coast, and it breeds in pools a little above high-water mark. These pools contain brackish water, in which there is generally an abundant growth of *Enteromorpha*. The present notes will be confined to the mating-habits, oviposition, and similar features of the insect.

Larvae, and often a few pupae, are to be found in the pools throughout the winter. In mild winters a few emergences may take place. During September pupation takes place somewhat more freely. Mating takes place among the newly-emerged insects; but it is usually not until October that it is in full swing. Although nothing that quite corresponds to the swarming of many other mosquitoes takes place, the surface of the breeding-pools becomes dotted, often quite thickly, with males. They adopt a very alert attitude, peering down into the water and often thrusting the head below the surface to get a clearer view. Their object is to capture the female pupae that are about ready to emerge. If the surface of the water is broken by a rising pupa a few inches away, the male darts at the spot with wonderful quickness. The capture of the pupa is made by means of the anal forceps, the great ungues of the male not being used in these circumstances. The grip is usually secured on the frontal ridge, along which the puparium would split in a case of unaided emergence; but often the grip is to one side of the ridge. In either case the puparium is ruptured a little to one side of the ridge, and the anal forceps of the male rest upon the thorax of the pupa, working backwards and extending the slit. In a few cases the slit is greatly extended, but generally the male ceases active efforts in this direction as soon as the head and part of the thorax are clear. Emergence from this point is generally effected by the gradual straightening of the legs of the young imago, which rises slowly and steadily, without jerky movement, till nearly the whole of the abdomen is clear. The male has kept the forceps in close contact with the body of the imago, two or three segments of his abdomen being inside the puparium. If, as is usually the case, the imago is a female, connection is effected before her abdomen is quite clear, and when emergence is complete copula has already begun.

While it is in progress the two insects rest quietly, in the end-to-end position, on the water or on a rock. Copula usually lasts from three to seven minutes, but it has been observed to last over half an hour.

It is by no means an uncommon thing for a male pupa to be captured, and in this case the captor does not discover his mistake until emergence is about complete. He then darts away, one can fancy, with an expression of disgust, and after a little time resumes his place among the hunting males.

When swarming is active it never happens that a captor is allowed undisputed possession of the captive. Three or four or a dozen other males will have leapt at the same time, and a fierce struggle takes place, the successful captor making for the shore, stabbing with his proboscis and dragging the struggling mass along. The competitors seem to use their ungues in thrusting or dragging each other away, and the proboscis is apparently used freely. But the struggle never lasts long. Apparently it is abandoned as soon as it is recognized that the captor has a sufficient hold with the forceps to prevent loss of the captive. I have never seen a competitor injured in the struggle, or, at all events, so injured that he could not at once return to the occupation of watching for a pupa. Whether the original captor is ever dispossessed during the struggle I cannot say, but probably if the rivalry were never successful it would not exist. One occasionally sees two males with a hold on the same pupa, dragging in opposite directions. In these cases the one that drags the pupa head forward is successful.

From a long series of observations it seems evident that the method of the copula is usually the one just described, and that fully emerged females may be supposed, as a rule, not to copulate a second time. The following extracts from my notes refer to observed departures from this apparent rule and to the sensitiveness of the male to interruption.

27th September, 1921: At 11.45 saw another male holding a pupa as before, but between the spiracles, though close to the left one. I put the couple in a phial half filled with water, and shook it violently till they separated. The male made no further attempt to capture the female, which, in a quarter of an hour, completed her emergence without effort. I drained off the water and kept the couple under observation for an hour. Neither took the least notice of the other.

I repeated these experiments several times on this and subsequent days, and never found that connection was resumed. I have also separated pairs just as copula was about to be established, and others just after it had begun. With two exceptions, one of which is about to be referred to, they have remained indifferent to each other, and the females, removed to a tank containing a large number of hunting males, excited no attention.

One of the two exceptional cases of resumed copula just referred to demonstrates hypertrophy of the sexual instinct in a male. The note is as follows:—

At 10.20 p.m. (3rd October, 1921) noticed in a mating-tank over which an electric light was placed two insects in full copula. I placed them in a phial with some water. They immediately separated. From the appearance of the female I judged that she had emerged some minutes before, and I supposed that copula had about come to an end. At 10.40, the phial having for some five minutes been unobserved, I saw that renewal had taken place. I moved the phial to get it in a better light, and the insects again

separated. Three minutes later the male darted at the female and seized her, using the ungues and the anal forceps. A struggle ensued, during which the female was forced partly under the surface. Copula was again established, and it lasted for seven minutes. After separation had taken place, and within five minutes of it, a fresh connection was established, with the like preliminary struggle. This lasted for five minutes. On both occasions the normal end-to-end position was assumed, both standing on the water. Five minutes after separation the male again seized the female and established connection, which he immediately broke off. I have placed the female in a separate jar to note whether eggs are deposited. (None were deposited). On the next day the male was quite ready to repeat the above performances with another female. After keeping him under observation for a day or two I thought the proper thing to do was to kill him.

Another exceptional case was the following: On the 1st October I saw a male that had been darting about actively in a mating-tank pounce upon a female that was resting on the surface and effect immediate connection, apparently with no great difficulty. He ran straight forward, as if he had seized a pupa. The effect was to turn the female back downwards in the water, and by the time the resting-stone was reached her wings were thoroughly draggled. I removed them to a phial, and they separated five and a half minutes after the capture. The female could not clear her wings. Later I placed her upon a piece of blotting-paper, but she did not recover. During copula the forceps of the male could not, on account of the unusual position, grip the last segment of the abdomen of the female, as in the normal position, but nearly met below it. Yet the dragging of her body through the water, and the subsequent struggle during the isolation of the couple, did not cause separation. During two summers I have often watched the mosquito-pools, and have never witnessed the capture of an imago, and, except for the case last noted, this is the only case I have witnessed in the laboratory.

Although the pupa may be seized by the frontal ridge or crest, the slit is made by the male just to one side of it, usually the left. But when a pupa emerges unaided, whether it be male or female, the puparium opens along the crest.

Males sometimes capture immature pupae, and in that case they seem unable to rupture the puparium. But these cases are rare, partly because the males sometimes discriminate and partly because the immature pupae are more active in avoiding capture. When the pupa is mature, air accumulates between the puparium and the new cuticle, until the only connection is at the spiracles. The pupa then has a silvery-white sheen, and is easily recognizable by the observer. Its vision is impaired, and also its power to struggle. It is therefore easily captured.

Neither male nor female pupa has the least difficulty in quitting the puparium unaided. The following note shows the course of things as frequently observed in the case of pupae that have been isolated: The pupa resting at the surface of the water began emergence from the puparium. The groove along the crest that runs backwards along the dorsum of the head and thorax deepened to a slit, and through this the head of the pupa began to emerge. The limbs and wings could be seen folded close to the body. By the straightening and expansion of the legs as they became more exposed to the air the head and thorax were steadily pushed, as it were, upwards. Presently the first pair of legs

was freed by a single effort. Immediately the insect spread them, and they rested on the surface of the water. The other legs were steadily drawn out, and only the last two or three segments of the abdomen were now within the puparium. The puparium was now seized between the hind legs and thrust backwards, floating away. Within half a minute of clearing itself the imago walked away. The whole process, from the first appearance of the head between the sides of the cleft, occupied just under four minutes. As the insect emerged it was of a whitish colour, turning rapidly greyish-white, the only black being in the form of bands on the legs. Soon these were as wide as the white, and then wider, until the only white on the legs was in the form of the narrow bands at the joints as in the adult insect. Meanwhile dark spots appeared at the spiracles, and these rapidly spread. Within five minutes the whole insect was a greyish-black, and within another five it was practically black. On emergence the wings flattened at once, but did not extend the full length of the abdomen, the last two segments of the abdomen being quite uncovered. Within ten minutes the wings were the full length of the abdomen, and in another five they had extended beyond it to the full length of the adult wing.

The male imago does not commence hunting for pupae immediately on emergence from the puparium, but may do so within ten minutes, and usually does so within twenty.

I have for several summers examined the pools, and the rocks that border them, together with any growth of weeds, in the hope of finding the eggs, but always without success. During the early part of last summer very young larvae made their appearance in a mating-tank, and it was evident that eggs had been deposited. On the 7th March I placed newly emerged insects, male and female, in a large cage resting over a dish of water with a white oyster-shell rising above the surface. On the evening of the 10th, at 9 p.m., a female was observed resting on the shell at the edge of the water. Now and again the abdomen was raised and then lowered to the water and brushed with the femur and tibia of the hind legs. I could not, without withdrawing the dish, which I did not wish to do, see any eggs. In about fifteen minutes she flew up into the cage. Next morning I found attached to the shell at the spot where she had been resting, and just below the surface of the water, a group of five tiny eggs. They were black, and easily seen against the white shell, as I had hoped they would be. At another spot there was a group of seven, and eight others were found singly at different spots. All were very lightly attached. There were also nine eggs floating in the water. These floating eggs looked spherical, though in reality oval, the spherical appearance being due to the fact that one end of the egg, the narrow end, was downward. The attached eggs had short blunt " processes " of the shell in contact with the oyster-shell, and the floating ones had similar " processes " on one side. These " processes "—if indeed they are really processes and not an independent secretion from glands of the female—were colourless. The floating eggs had probably become detached owing to the comparatively smooth oyster-shell not being a suitable surface for attachment. The five eggs of the first group, together with one that was lying on the floor of the dish, were removed to a phial to enable me to watch them. The dish containing the oyster-shell was taken away and the eggs kept under observation, another dish, containing a piece of white sandstone, being substituted.

On the 13th March about a dozen eggs were found attached at the water-edge to the sandstone, and not grouped. Next day about a hundred more were observed. Deposition of eggs on this stone continued until the 19th.

The eggs are oval, broader at one end than at the other, and covered with minute blunt spinous processes. They have also the colourless "processes" of mucilaginous matter already referred to. They vary slightly in size, but the usual length is 0·45 mm. and the greatest breadth is usually 0·3 mm. (Fig. 1.)

With regard to the eggs first deposited on the 11th March: By 10 p.m. on the 18th none had incubated; but at 10 a.m. on the 19th a single larva was found in the phial. This I killed and mounted. These eggs, and those left on the oyster-shell, were kept under observation until the end of the month; but no further incubation took place. The eggs were then thrown away.

The eggs on the sandstone block were observed constantly until 10.30 p.m. on the 24th. On the 25th no observation was made. At 10 a.m. on the 26th two larvae were found in the dish, evidently incubated not more than a very few hours earlier. As none of these eggs were deposited before the evening of the 12th March, the incubation period had been about fourteen days, as against eight days in the first case. Between 4 and 5 o'clock on the same day two more completed incubation, and four more next day. The dish had been removed from under the cage. Up to the middle of April no further incubation took place, and I supposed that there would be no more. On the 15th September, however, I found in the dish about a dozen very young larvae, and others appeared from time to time during the next four weeks. Probably about 10 per cent. in all of the eggs on the sandstone block incubated. None have incubated since the 15th October.

From these observations it is evident that hibernation may take place either in the larval stage or in the egg.

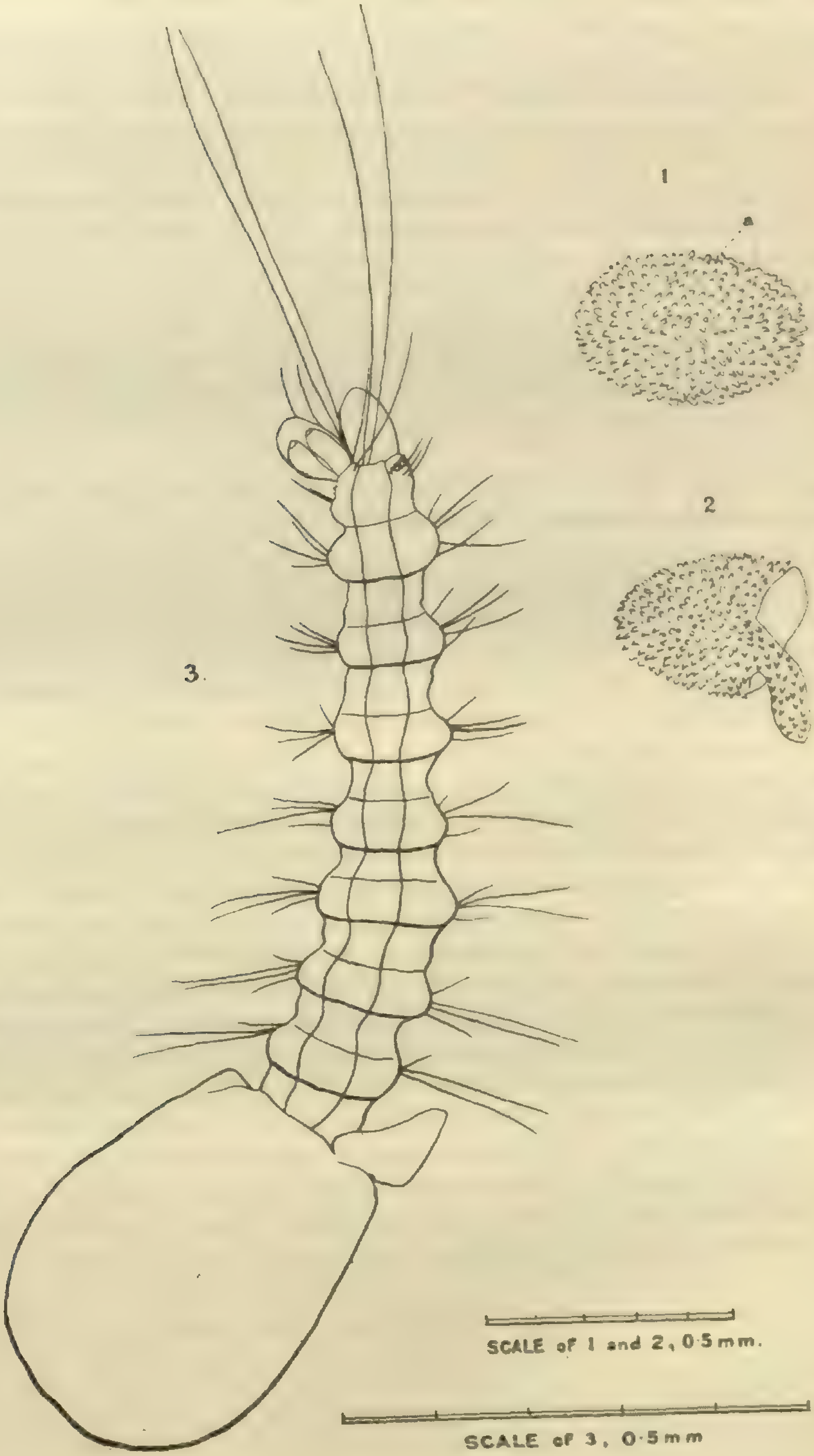
The first moult takes place not earlier than three weeks from the egg. The time varies greatly, but I do not give full notes of dates, as it is probable that the times would not be the same in the open pools. The second moult in hibernating larvae in the laboratory was about the end of August, or a little earlier; pupation began the first week in September, and the first imago appeared on the 17th.

In incubation the egg generally opens at the broad end, and the empty egg-shells have always a flap thrown back, leaving quite a wide opening. I have failed to find in the fresh eggs any indication of the line along which the "dehiscence" takes place. (Fig. 2.)

The larva leaves the egg tail first. This is obviously quite a suitable plan for a mosquito that has the eggs firmly attached. I have not been able to witness the actual opening of the flap, but I have found a larva that had most of the body clear though the head and thorax were still inside the shell. The egg had in this case become detached, and the larva was having some difficulty in getting clear. (Fig. 3.) Presumably he would have succeeded if I had not killed and mounted him.

It is not within the scope of this note to deal with the early stages of embryonic development; but it is of interest to note that six days after copula the eggs in the ovarian sacs are round, and that a thin shell, which is also round, is already formed.

In September of this year I isolated over a dozen females that had emerged in copula, giving them the most favourable conditions I could



Opifex fuscus.

FIG. 1.—Egg: *a*, mucilaginous elevations for attachment.
FIG. 2.—Empty egg-shell.
FIG. 3.—Larva quitting egg, in this case by the narrow end.

devise for the laying of eggs; but altogether without result. It would appear that it is only rarely that eggs are laid in captivity.

Seeing how crowded the pools are with larvae during the greater part of the summer, it is surprising that the number of adults at the different pools remains about the same. Even towards the end of summer, though a pool may be crowded with larvae, there do not seem to be more adults than one sees in November. It is probable that the normal life of the adult is short; nevertheless, I have kept both male and female mosquitoes alive in the laboratory for over three weeks.

Another feature that strikes one as singular is the apparently capricious preference given to certain pools. These favourite pools are always found to be occupied, while others, apparently equally suitable, are either not occupied at all, or are occupied in some years and not in others.

The following extract from my notes does not properly come within the scope of this paper, but it seems to me to be of sufficient interest to warrant publication :—

2nd October, 1921: When watching the mating-tank, observed at 4 p.m., an imago standing completely submerged on the side of the resting-stone, head downwards. I endeavoured to take the insect by means of a pipette; but it immediately walked down the rock till it was 4 in. below the surface, then walking along an almost horizontal surface, back downwards, to a smaller stone that rested on the floor of the tank. It clung so tightly that, even at this depth, it resisted the suction of the pipette for several attempts. At last I secured it, and put it in a phial for examination. It did not stand on the water, but lay on its side with draggled wings. It proved to be a female, newly emerged, the abdomen still greyish. I put the insect on a stone in a jar of brackish water. She immediately walked down into the water, pausing now and again to stroke the head and wings with the legs, as if endeavouring to dislodge the film of air that adhered to them. She remained on the sloping stone about 2 in. below the surface, apparently in comfort. She remained in this position till 4.31, when she loosed her hold and floated to the surface, almost motionless there. I placed her on the stone; but she did not recover. It may be supposed that the larva, making the complete change of bodily structure necessary for aerial life, and making it with apparent success, had failed to make the subtle change of instinct that should have accompanied the change of structure. Next morning, finding that she had not recovered, I fixed with mercury bichloride in 30 per cent. alcohol, hoping that some one that has a more complete knowledge of the histology of the nervous system of mosquitoes may be able to make use of it.

ART. 30.—*A Contribution to the Study of New Zealand Leaf-hoppers and Plant-hoppers (Cicadellidae and Fulgoroidea).*

By J. G. MYERS, F.E.S., Biology Division, Department of Agriculture.

[*Read before the Wellington Philosophical Society, 25th October, 1921; received by Editor 31st December, 1921; issued separately, 30th April, 1923.*

PROBABLY few New Zealand insects have been so generally neglected by entomologists as those usually small but abundant forms which comprise the division Auchenorrhyncha of the Hemiptera-Homoptera. Although the comparatively large and at least audibly conspicuous Cicadidae have received some considerable attention, the other families have been so little collected that a comprehensive monograph of the division is at present out of the question. The present paper is an attempt to bring up to date our knowledge of a few of the subfamilies as a basis for future taxonomic and biological work.

It will be advisable firstly to indicate briefly the exact connotation of the popular terms "leaf-hopper" and "plant-hopper." The following classificatory sketch of the Auchenorrhyncha will make this clear:—

Superfamily 1. Cicadoidea.	
Family Cicadidae ..	.. Cicadas, or singers.
Family Cercopidae ..	.. Frog-hoppers.
Family Cicadellidae	.. Leaf-hoppers.
Family Membracidae*	.. Tree-hoppers.
Superfamily 2. Fulgoroidea	.. Plant-hoppers.

In this paper a revisional account is given of three subfamilies of the Cicadellidae and one family of the Fulgoroidea. The relative value of the families and subfamilies is a debatable matter, in which I have followed Mr. F. Muir, to whom I am deeply indebted for specimens, determinations, literature, and unpublished information, which he has generously and unreservedly placed at my disposal. A list of those who have helped me in New Zealand, particularly with collections, would include most of the working entomologists of the country. Mr. E. H. Atkinson has also collected much valuable material. Since this was written Professor C. F. Baker has been most generous with help and advice.

I. CICADELLIDAE (Leaf-hoppers).

Syn. JASSIDAE, TETIGONIIDAE, *auctt.*

Of this large family only two species have hitherto been described from New Zealand, of which one is extremely rare, while the description of the other, founded on damaged material, is difficult to identify with any known species. The following key includes all the subfamilies of Cicadellidae known to me to be represented in New Zealand, but new species are continually coming to light. The Cephalelinae, Typhlocybinae, and Tettigoniellinae are dealt with in the following pages; the other three subfamilies will be treated, it is hoped, in a later communication. With regard to the venation I have followed Tillyard in regarding vein 1st A of Metcalf (1913) as really Cu_2.

* Not, as far as is known, represented in New Zealand.

Key to New Zealand Subfamilies of Cicadellidae.*

(Applicable to New Zealand species only.)

1. Head very strongly produced; legs feebly spinose or only bristly	Cephalelinae.
Head not strongly produced; hind tibiae strongly spinose ..	2
2. Veins of tegmen running without branching to apical cross-veins	Typhlocybinae.
Veins of tegmen branching on the disc	3
3. Ocelli situated on dorsal part of head, away from anterior margin	Tettigoniellinae.
Ocelli on border of vertex or on margin between vertex and frons	Jassinae.
Ocelli on front, distinctly on ventral side of head	Bythoscopinae.
Ocelli in groove below anterior edge of vertex	Paropiinae.

Subfamily 1. TETTIGONIELLINAE.

Genus 1. Diedrocephala Spinola. (Fig. 2.)

Diedrocephala cassiniae n. sp. (Fig. 4.)

Short and squat, especially the male. Pale olivaceous brown with whitish streaks and spots. Ocelli pink.

♂. Vertex more than twice as wide as medianly long. A fairly deep depression lateral to each ocellus; a depressed median longitudinal line; a slightly raised circular area on each side ornamented with more or less concentric striae; several rather deep longitudinal striae on each side of medial longitudinal striation; both anterior and posterior border slightly raised, the former narrowly edged with fuscous. Pale testaceous with three fuscous spots about middle of fore-border and a few yellowish-brown blotches on the disc. Edge between vertex and frons acute. Fore-border of vertex roundly and very obtusely angulate.

Pronotum transversely striate, pale testaceous irregularly marked with yellowish-brown and fuscous, the latter towards posterior margin, which is long and sinuately but slightly emarginate.

Scutellum divided transversely into an anterior striate portion with depression on each side of median longitudinal line, and blunt posterior apical portion very shiny and less striate. Scutellum somewhat shorter than pronotum.

Tip of abdomen barely visible beyond folded tegmina.

Tegmen extremely variegate with white, fuscous (almost black), and brownish. Veins white, edged either interruptedly or continuously with fuscous. Discal portion of each cell yellowish or olivaceous brown. White spots alternating with fuscous spots along the costal margin, each spot extending back to first vein (radius). First apical cell wholly white.

Hind tibiae with two rows of long amber spines with fuscous bases, about ten spines in each row.

Frons elliptical, gently convex. Antennae-pits fuscous. Joints of antennae amber.

Genitalia fuscous with bands of dark yellow.

Length, 4 mm.

♀. As male, except in following characters: Vertex as long as pronotum. Whole of last ordinary abdominal tergum visible beyond tips of folded tegmina. Often two oblique white bands on each corium.

* These subfamilies are not of equal rank. The Cephalelinae and Typhlocybinae are closely related to the Jassinae

Genitalia — Lateral plates yellowish spotted with fuscous. Ovipositor fuscous, scarcely projecting beyond last unmodified tergite. Dorsal surface of abdomen fuscous. Length, 5 mm.

Nymph. — Varying in colour from brownish-olive to green, thickly sprinkled with short stubbly glistening hairs. A darker depressed spot on each side of each abdominal tergite. Vertex produced much more than in imago; anterior border thin, foliaceous, with fuscous-tipped acute angle projecting cephalad of each eye, and with a row of five or six more or less distinct brownish blotches along anterior edge.

Described from eleven males and nine females.

Common in vast numbers on tauhinu (*Cassinia leptophylla*) and *Olearia Solandri* on the sea-coast, Wellington, October, November, June.

Holotype and allotype, with eighteen paratypes, in Myers collection, Biology Laboratory (No. 25).

D. maorica n. sp. (Fig. 6.)

General macroscopic appearance uniform yellowish-testaceous. A very distinct species.

♂. Vertex pale stramineous slightly clouded with yellowish. Median suture strongly marked. Coarsely but sparsely punctate, with a few striations near each eye. Ocelli pink. Eyes uniform fuscous. Vertex about twice as broad as medianly long—if anything, a little less. Fore-border acute but rounded. Edge between frons and vertex very acute.

Pronotum a little longer medianly than vertex. Colour similar to that of vertex. Anterior half with a median striation and a few coarse punctures; posterior half transversely and distinctly striate. Hind-border sinuately but very slightly emarginate.

Scutellum small and short, pale-yellowish, with a brown-tipped, suddenly narrowing but rather long apex.

Abdominal terga uniform pale-olivaceous.

Tegmen narrowing slightly towards tip, which is rounded. Almost uniform pale-yellowish, with indistinct whitish spots along the veins (eight, for example, along claval suture), and one or two cross-veins similarly pale; but all these markings very indistinct.

Wings far less hyaline than in the other species; cells filled with pale-brownish, veins themselves quite clear.

Hind tibiae armed externally with two rows of yellowish spines with brownish bases on an otherwise colourless tibia—eleven in one row and six or seven in the other.

Frons elliptical, pale uniform stramineous, as are also the antennal pits.

Genitalia concolorous with the rest of abdomen and likewise shining.

Length, 5·4 mm.

Described from one male.

Wainuiomata, 12th February, 1921; Mr. G. V. Hudson.

Holotype in Myers collection, Biology Laboratory, Wellington (No. 192).

D. zealandica n. sp. (Fig. 3.)

A large and easily recognized though very variable species. General colour brownish, speckled with fuscous and white.

♂. Vertex almost as long laterally as medianly—*i.e.*, only very slightly produced; about four times as wide as long. Ocelli red. Fore-border rounded, edge fuscous and slightly upturned. Colour warm brownish, with a few irregular smoother yellowish areas. Very slightly granulate on disc.

Pronotum three times as long as vertex. Anterior portion with a wide shallow depression on each side; transversely sinuately striate; pallid-testaceous, heavily marked with blotches of coffee-brown and irregular spots and streaks of fuscous; fore-border rounded; hind-border with a slight very obtusely angulate emargination in middle and abrupt angular bend cephalad on each side.

Scutellum brownish with a fuscous spot on each side of base. Apex acute and narrow, nearly as long as pronotum.

Tegmen long, narrower at tip, which is rounded. Testaceous, all veins fuscous, dotted with hyaline white roundish spots, very distinct—about eleven along costal margin and four on termen. A large white spot at end of subcosta connecting by white irregular markings larger than vein-spots to a large white spot in distal angle of clavus. *These two spots are very distinct.*

Hind tibiae with two rows of fuscous-based amber spines, about nine in each row.

Frons elliptic-oblong, practically plane. Juncture with vertex acute, edged ventrally with yellow, followed by an irregular fuscous band notched upward in middle and followed in its turn by a second yellow band curving above antennae-pits.

Length, 6 mm.

♀. Resembles ♂; but vertex is slightly longer and the white areas on tegmen frequently more extensive and less sharply defined, sometimes rendering half the area of tegmen hyaline. The closed tegmina completely cover the abdomen even in this sex. Length, 7 mm.

Described from one male and four females.

Dun Mountain, Nelson, 2,000–2,500 ft., January, March; Mr. A. Philpott! Wellington, January; Mr. H. Hamilton! J. G. Myers.

Holotype and paratypes in Myers collection, Biology Laboratory (No. 190). Allotype in Cawthron Institute collection, Nelson.

D. tararua n. sp.

General colour testaceous or dark greyish-olivaceous. Two oblique white bands on corium, one tipping the tegmen distally.

♀. Vertex considerably less than twice as wide as medianly long; strongly punctate with large shallow punctures. One specimen slightly granulated on disc of vertex. Ocelli pinkish-red. Vertex considerably produced but rounded.

Pronotum—Anterior portion somewhat depressed, with two deeper depressions on each side and a median longitudinal striation extending rather less than third of distance from fore-border. Posterior portion of pronotum somewhat transversely striate, with distinct circular deep dark punctations along each furrow. A median longitudinal area somewhat free of these striae and punctations. Hind-margin sinuate, slightly and roundly emarginate, with indications of four obscure fuscous patches evenly spaced.

Scutellum about three-quarters length of pronotum, which latter is itself co-equal with vertex. Anterior portion of scutellum with a median longitudinal groove meeting a transverse groove at about $\frac{1}{3}$ to form an indented inverted T. Posterior portion more elevated, curving suddenly at $\frac{2}{3}$ from base of scutellum to form a long, narrow, acute apex which forms a third of total length of scutellum. Whole scutellum with indications of transverse striation.

Tegmen short and broad, apically rounded. Pale-brownish, with the following areas fuscous: two or three irregular patches near base (sometimes absent), three more or less confluent spots making an irregular oblique band at half-way, and veins of ante-apical cells also fuscous. At about ⅓ is a more or less hyaline patch, followed by two more very distinct hyaline areas forming a band at ⅔ and at tip respectively. Outer margin of clavus or dorsum of tegmen with two fuscous areas separated by two whitish spots.

Hind tibiae with two rows of dark-amber spines sometimes with dark bases, eight or nine spines in each row.

Frons oblong, slightly convex. Antennae-pits nearly black. Basal joints of antennae yellow.

Genitalia uniformly testaceous or brownish.

Closed tegmina leave exposed the whole of the last unmodified tergite and much of the penultimate.

Length, 5·5–6 mm.

Male unknown.

Described from two females.

Tararua Range (Mount Alpha and Bull Mound), Wellington Province, 3,300–3,600 ft., February.

Holotype and paratype in Myers collection, Biology Laboratory (No. 189).

D. dunensis n. sp.

A small species easily distinguished by the very pale greenish colour almost obsoletely flecked with fuscous, and by the dark eyes.

♀. Vertex twice as wide as medianly long. Median suture distinct. Disc irregularly corrugate and punctate as in *D. hudsonica* n. sp. A very pale sea-green with a few indistinct smudges of pale brown. Ocelli red and prominent. Eyes almost wholly black, with a slight edging of greenish. Fore-border of vertex with fuscous edging narrower than usual, acutely rounded, but not so much produced as in *D. hudsonica.* Two small deep pits, one on each side of caudal end of median suture. Actual edge of vertex and frons quite abrupt, but angle not acute.

Pronotum about as long as vertex. Anterior third with a median line interrupted by a deep and wide median depression flanked antero-laterally by two calluses. Posterior portion transversely striate, with fuscous spots in grooves. Disc pale olivaceous-green, with a few brownish smudges. Hind-border very slightly not angulately emarginate, sinuate.

Scutellum large, with a smooth glassy anterior portion separated by a convex line from the short sharp apex, as in *D. hudsonica.* Disc pale olive-green. Median length about that of pronotum.

Abdomen pale greenish-olivaceous with segmental margins paler.

Tegmen very pale greenish, almost colourless, with very infrequent small fuscous spots scattered irregularly and surrounded narrowly by pale-brownish smudges. Outer edge of clavus with beginning of a broken dark-brownish line. Tip of tegmen somewhat truncate.

Wing as in *D. hudsonica.*

Hind tibiae armed externally with two rows of spines containing respectively ten and eight.

Frons shield-shaped as in *D. hudsonica*, with pale stripe on cephalad portion extending along cephalad edge of antennae-pits, which are pale,

edged with brownish. Disc of frons pale olivaceous with brownish lateral transverse striations not meeting across middle.

Genitalia concolorous with rest of abdomen, except ovipositor, which is darker and projects slightly, and ultimate ordinary tergite, which is laterally marked with brownish.

Length, 5 mm.

Described from one female.

Dun Mountain, Nelson, 3,000 ft.; Mr. A. Philpott.

Holotype in Myers collection, Biology Laboratory (No. 197).

D. hinemoa n. sp. (Fig. 5.)

Short and squat, the tegmina and wings small. Tegmen with two white areas separated by a transverse dark patch.

♂. Vertex considerably more than twice as broad as medianly long. Anterior border smooth, slightly upraised, and narrowly bordered with fuscous; disc of vertex irregularly corrugated, with a depression on side near each eye and three longitudinal striae between ocelli, which are dull-pinkish. Vertex uniform olivaceous. Fore-border roundly and obtusely angulate. Edge between vertex and frons acute but passing immediately ventrad into a rounded curve. Eyes variegate, olivaceous and fuscous.

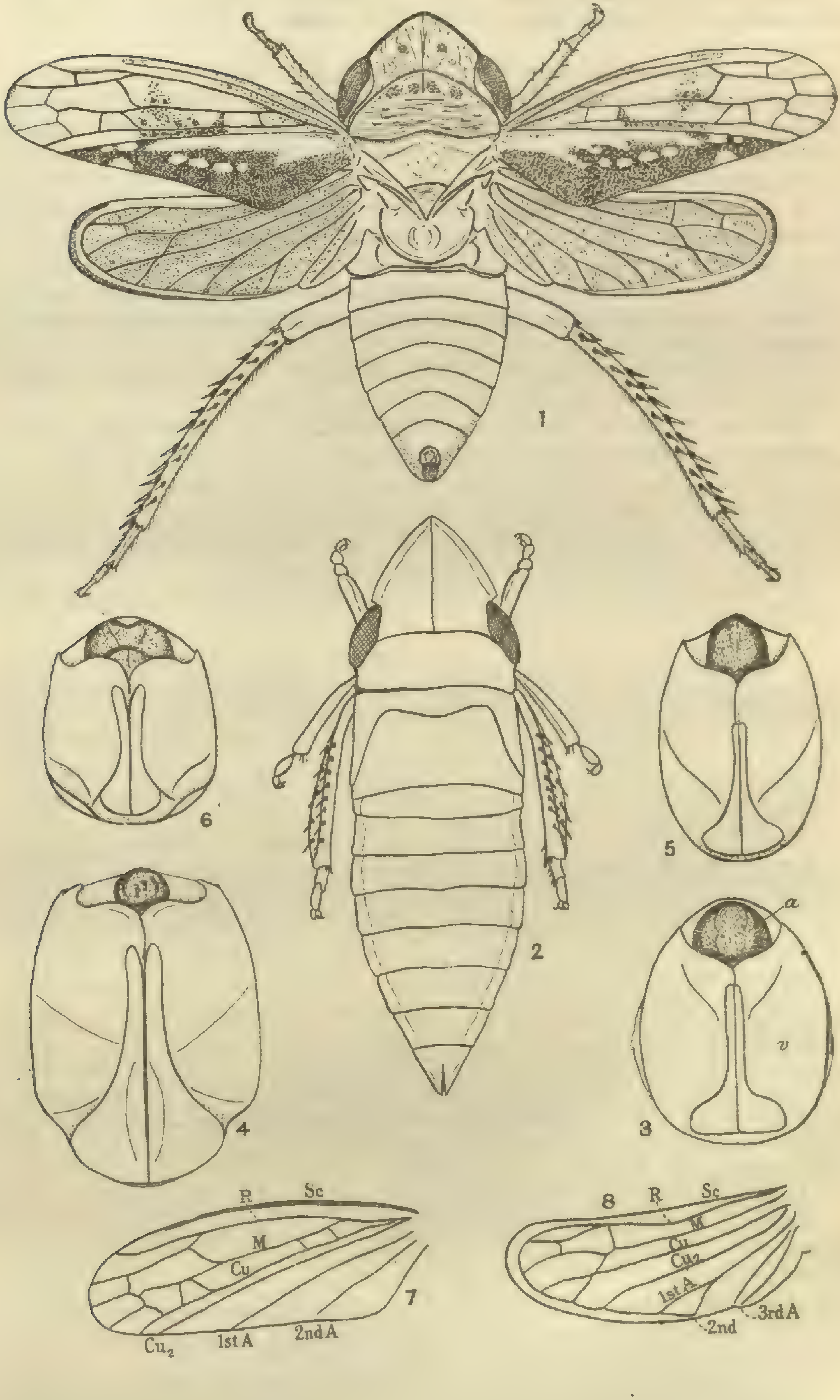
Pronotum irregularly transversely striate; a median transverse depression, shallow, but wide near fore-border; on each side of this a smaller thumb-print-like smooth depression. Pale olivaceous, the above depressions brownish with flecks and spots of castaneous and fuscous irregularly disposed on disc, especially *along* striae. Posterior border slightly emarginate in an angulately sinuate manner. Pronotum longer than vertex.

Scutellum somewhat shorter than pronotum; finely and evenly corrugate, with transverse line at ⅓ from apex and large cloudy fuscous spot on each side of base.

Abdominal terga—First two pale semitransparent olivaceous; remainder fuscous, almost black, except genitalia, which are paler.

Tegmen—Base with a few cloudy brown marks and spots, especially round bristles; next a wholly white area, in which even veins are not picked out; then follows a yellowish-brown portion in which veins are marked and widely bordered with fuscous and punctations even darker, followed by another colourless area of varying width and irregular shape, after which veins at tips and for a short distance before are widely fuscous, the space between them being brownish-yellow except on termen itself, which is wholly but narrowly edged with fuscous. Anal angle filled with brownish-yellow, the punctations fuscous.

Fig. 1.—*Diedrocephala hudsonica* n. sp.: female.
Fig. 2.—*Diedrocephala* sp.: last nymphal instar.
Fig. 3.—*Diedrocephala zealandica* n. sp.: ventro-caudal view of male pygophor. *a*, anal segment; *v*, valve.
Fig. 4.—*D. cassiniae* n. sp.: ventro-caudal view of male pygophor.
Fig. 5.—*D. hinemoa* n. sp.: ventro-caudal view of male pygophor.
Fig. 6.—*D. maorica* n. sp.: ventro-caudal view of male pygophor.
Fig. 7.—*D. hudsonica* n. sp.: tegmen. } Sc = subcosta; R = radius; M = media
Fig. 8.—*D. hudsonica* n. sp.: wing. } Cu = cubitus; A = anal.


1
2
6
5
4
3
a
v
R
Sc
M
Cu
Cu2
1st A
2nd A
7
8
R
Sc
M
Cu
Cu2
1st A
2nd
3rd A

Hind tibiae armed externally with two rows of long amber spines with dark bases, eight in one row and nine in the other. Internally a row of bristles.

Frons oblong, very gently convex; olivaceous with numerous semi-transverse irregular black marks. Antennae-pits black.

Genitalia olivaceous marked with fuscous. Eighth abdominal sternite yellowish.

Length, 5 mm.

♀. Resembles male except in the following characters: Eyes wholly fuscous except for olivaceous edging. Colour altogether more greenish on head and thorax, with numerous fuscous flecks on vertex. Darker areas of tegmen have occasional or even frequent clear white roundish spots. Ultimate and penultimate ordinary terga mottled with muddy brown. Length, 5·5 mm.

One male, Nelson, January; Mr. A. Philpott. Three females, Mount Arthur Tableland, Nelson, February; Mr. A. Philpott.

Holotype (male) in Myers collection, Biology Laboratory (No. 191). Allotype in Cawthron Institute collection.

D. hudsonica n. sp. (Figs. 1, 7, 8.)

A rather large species with pointed vertex and pale tegmina with a broad chocolate band along the outer border of clavus.

♀. Vertex less than twice as broad as medianly long. Irregularly and coarsely corrugated and punctured. Median suture distinctly marked by several ridges and depressions. Fore-border, as usual, edged narrowly with shining fuscous; *acutely* rounded. Eyes variegate with fuscous and grey, anterior portion wholly fuscous. Ocelli pinkish with pale centres, each ocellus somewhat on the side of a wide and fairly deep depression. Disc of vertex shining yellowish-brown inclining to olivaceous. Edge between vertex and frons abrupt and fairly acute, but passing immediately ventrad into a rounded curve.

Pronotum about as long as vertex or very slightly shorter; anterior half with almost smooth surface, but with median longitudinal line flanked on each side by a transverse rounded callus, which forms on each side the anterior border of a slight depression. There is a deeper depression lateral to each callus. Posterior portion transversely striate with wide grooves containing occasional fuscous punctations. Disc of pronotum concolorous with vertex. Hind-border slightly emarginate and sinuate with no trace of angularity.

Scutellum large, with a roundly curved anterior surface of pale olivaceous clouded faintly with fuscous, and separated from sharp brownish apex by a curved transverse depressed line with its convexity cephalad. Disc of scutellum with faint indications of irregularly concentric striation. As long as or a little shorter than pronotum.

Abdomen olivaceous, with segmental margins paler; very shining.

Tegmen coarsely punctate, especially along veins. Corium almost immaculate, whitish except for a pale-brownish suffusion on costal portion of basal third, and a few chocolate flecks about middle of claval suture and near bases of ante-apical cells. Clavus with anal angle and a wide irregular band reaching in width more than half-way to suture, dark brown or chocolate; remainder colourless.

Wings with the cells speckled with fuscous, but not heavily enough to mar the transparency. Veins clear.

Hind tibiae armed externally with two rows of yellowish rather short spines with dark bases, about eight in one row and thirteen in the other. Internally a row of bristles.

Frons shield-shaped, with cephalad portion somewhat pointed, passing caudad into a rounded swelling at each side, followed by slight constriction at $\frac{1}{3}$, where the typical elliptical curvature is resumed. Pale-olivaceous slightly clouded with pale-brownish. Antennae-pits pale-brownish.

Genitalia concolorous with rest of abdomen, except ovipositor, which is darker and projects slightly beyond ultimate ordinary tergite.

Length, 6·4 mm.

One female.

Karori, Wellington, February; Mr. G. V. Hudson.

Holotype in Myers collection, Biology Laboratory (No. 193).

Subfamily 2. CEPHALELINAE.

Tribe Dorydini Cogan, *Ohio Journ. Sci.*, vol. 16, p. 184, 1916.
Tribe Cephalelini Kirkaldy, *Bull. 3, H.S.P.A. Exp. Sta.*, p. 72, 1907.

This interesting subfamily is closely related to the Jassinae, of which it is frequently ranked as a tribe. I follow Kirkaldy in elevating it to equal rank with the other primary divisions of the Cicadellidae, although I consider all of them as subfamilies instead of tribes. It is distinct not only on account of the elongate or foliaceous head—a characteristic of widely separated genera in other subfamilies—but also in the "degradation of the flight-organs," the reduced venation, and the only feebly bristly tibiae. The hind tibiae of *Paradorydium westwoodi* F. B. White, however, bear, in addition to the bristles, a row of quite considerable spines. In connection with the reduced venation and alar degradation it is noteworthy that in *Cephalelus hudsoni* n. sp., although the tegmina are well developed and extend considerably beyond the abdomen, the wings are completely atrophied.

It is no exaggeration to say that the members of the two Cephaleline genera represented in New Zealand present as striking examples of Poulton's "constant, special protective resemblance" as are to be found. With regard to the African *Cephalelus infumatus* Perch., the description of which would apply in essentials to our own species, Osborn noticed that "the protective feature comes in from the fact that the aborted leaf-sheaths on the stem of the plant form sharp spines occurring at intervals along the length of the stem, and these are perfectly reproduced in the form and colour of the insect. So close is the resemblance that when a number of the spines are mounted separately alongside of the insects it is very difficult to distinguish them without the most careful scrutiny." The plant mimicked by this African species is the rush *Dovea tectorum* Masters. The stems are green, while the aborted leaf-sheaths are dark brown (Cogan, 1916). The disguise of the New Zealand species is no less perfect.

Of the four species of Cephalelinae so far found in New Zealand, one was described in 1879 by F. B. White, while the other three are new.

Key to Genera of New Zealand Cephalelinae.

Frons distinctly convex, often even strongly carinate	*Paradorydium.*
Frons concave; deeply excavated	*Cephalelus.*

Genus 1. Paradorydium Kirkaldy.

Kirkaldy, *Entom.*, vol. 34, p. 339, 1901.

Paradorydium westwoodi (F. B. White).

Dorydium westwoodi F. B. White, *Ent. Mo. Mag.*, vol. 15, p. 215, 1879; Signoret, *Ann. Soc. Ent. France* (5), vol. 10, p. 43, 1880; Kirby, *Trans. Ent. Soc. Lond.*, p. 411, 1894; Hutton, *Trans. N.Z. Inst.*, vol. 30, p. 185, 1898. *Paradorydium westwoodi* Kirkaldy, *Entom.*, vol. 34, p. 339, 1901; *ibid.*, *Trans. N.Z. Inst.*, vol. 41, p. 28, 1909.

F. Buchanan White's description is as follows: "Pale yellowish-ochraceous; head with a very slight tinge of brown; tarsi claws pale brown. Head and thorax finely punctate; tegmina coarsely reticulate-punctate or cribose between the veins. One example has a brown intramarginal streak from the base to the apex of the tegmina. Length, 14; breadth at base of tegmina, 2; length of head, 4 mm. Three specimens from Mr. Wakefield, with the ticket, 'Found by Mr. Fereday near Christchurch.' This curious species strongly resembles the seed of one of the larger grasses."

By the courtesy of Mr. G. Archey, of the Canterbury Museum, I have been enabled to examine specimens from the Fereday collection and from the Hutton collection.

Fereday's specimen measures 14 mm. in total length, with the head 4·5 mm. long, and agrees exactly with White's description, which may be amplified as follows: Head inclined upwards, but practically straight in itself except for a very slight upturning at the tip, with a faint rounded median longitudinal ridge. Tegmina tapering gradually to a very sharp point. Legs bristly, but in addition the hind tibiae have a row of seven or eight fairly strong spines on the upper outer edge. There is, unfortunately, no date, locality, or number fixed to this specimen.

The Hutton collection contains three specimens almost exactly similar except in size, their lengths being 11 mm., 11 mm., and 12 mm. respectively. The head is also rather more upturned at the tip and inclined to be very slightly spatulate apically. This is a sexual difference in *P. menalus* Kirk. from Australia (Kirkaldy, 1906, p. 339), so that I suspect these are males and the other (Fereday collection) a female; but all four are gummed so tightly by the whole of the ventral surface that I refrained from attempting to remove them for examination of the genitalia. The Hutton specimens have the date 1865, but no locality legible.

This is evidently a rare species. Besides the specimens referred to above, Signoret received some from John Scott, which according to Kirby (1894, 412) appeared to be "darker than the types" and were only 11 mm. long. Finally, a nymph and a male imago were sent to Kirby at the British Museum in 1894, with the following notes by Mr. H. Clarke, of Christchurch: "I found it on the rushes which grow in damp situations. In colour and shape it so much resembles a piece of dried rush that I have never been able to find a specimen except by switching the net amongst them. I think they are scarce and very local, as the specimens I have captured were taken in a space a few yards square, and I have never been able to collect them elsewhere. The place where they were found was in a plantation of *Pinus insignis*, about a quarter of a mile from the sea and a few chains from the river. The time of appearance is from the beginning of November to the end of the year."

I quote these local particulars from Kirby (1894) in the hope that collectors in Christchurch will endeavour to rediscover this interesting leaf-hopper.

Since this was written Mr. J. F. Tapley has taken two typical specimens at Governor's Bay, Banks Peninsula, and presented them them to me.

P. philpotti n. sp. (Fig. 9.)

♂. Pale olivaceous, without markings. Scutellum with a conspicuous black spot on each side. Elongate-fusiform, narrowing suddenly cephalad. Head more than half as long as nota and tegmina together, converging suddenly and then tapering to narrowly rounded apex; sides acutely carinate for at least anterior two-thirds. Punctation of head, pronotum, and scutellum almost obsolete. Tegmina coarsely but shallowly punctate, in a linear but inconspicuous manner; much longer than abdomen; convex; not sharply pointed at apex. Eyes pale. Frons and clypeus very convex. Legs relatively longer than in the other species. Ventral surface pale, with deep blackish lateral areas, especially on abdominal sternites. Genital valves uniformly pallid.

Length of body, 8 mm.; head, 3 mm.; greatest width, 1·4 mm.

A very distinct little species, for the only specimen of which, a male, I am indebted to the discoverer, Mr. A. Philpott, after whom I have much pleasure in naming it.

Hump Range, 3,000 ft., December.

Holotype in Myers collection, Biology Laboratory.

Genus 2. CEPHALELUS Percheron.

Percheron, *Mag. Zool.*, vol. 2, pl. 48, 1832.

Cephalelus hudsoni n. sp. (Figs. 10, 11, 12, 14.)

♂♀. Pale olivaceous varying through greyish-stramineous to yellowish-testaceous and greyish-brown, irregularly mottled with fuscous on sides of vertex, disc of pronotum, and tegmina. Mesonotum often greenish, with a dark spot laterally. Sterna buff, with abdominal sternites, rostrum, and genitalia darker. Genital valves, however, are pallid. The whole surface shows occasional black specks. Shape elongate-fusiform. Head exactly half as long as nota and tegmina together; gradually converging towards apex, which is extremely slightly spatulate. Head concave beneath and convex above. Head, pronotum, and scutellum sparsely and almost obsoletely punctate, except a median longitudinal line on vertex which is smooth. Head exactly porrect. Tegmina with larger but shallow, dark-coloured punctations. Eyes black, not protuberant. Tegmina much longer than abdomen, tapering rather suddenly to a very sharp point. Wings practically absent, represented by two white membranous flaps less than $\frac{1}{5}$ mm. long. Legs short and similar, concolorous with the body. The whole upper surface, when tegmina are folded, is remarkably smooth, convex, rounded, and free from keels. Upper surface of abdomen dark.

Length: Male, total length, 10 mm.; head, 3 mm.: female, 11–11·5 mm.; head, 3·7 mm.

Wellington, October to March.

Discovered by Mr. G. V. Hudson, to whom I have much pleasure in dedicating it, and subsequently collected by myself, on a small patch of the jointed rush (*Leptocarpus simplex*) at Breaker Bay, Wellington.

A second locality is Gollan's Valley, Wellington, also near the sea. I have not found it on any other food-plant, nor even on the same food-plant in other similar localities in the same district. The males appear to be rare: I have only one male among some twenty-eight females; but as my specimens were nearly all collected early in October it is quite possible that the females had appeared first and the males had not reached their maximum of abundance.

As has been noticed in connection with *Paradorydium westwoodi* and *Cephalelus leptocarpi* n. sp., the insect is frequently (always, in my experience) confined to a very small patch, though there may be large areas of the food-plant, which grows often in pure associations, in the immediate vicinity.

The adults are rather sluggish, but are capable of leaping some distance, though the posterior legs are apparently very little specialized for this purpose.

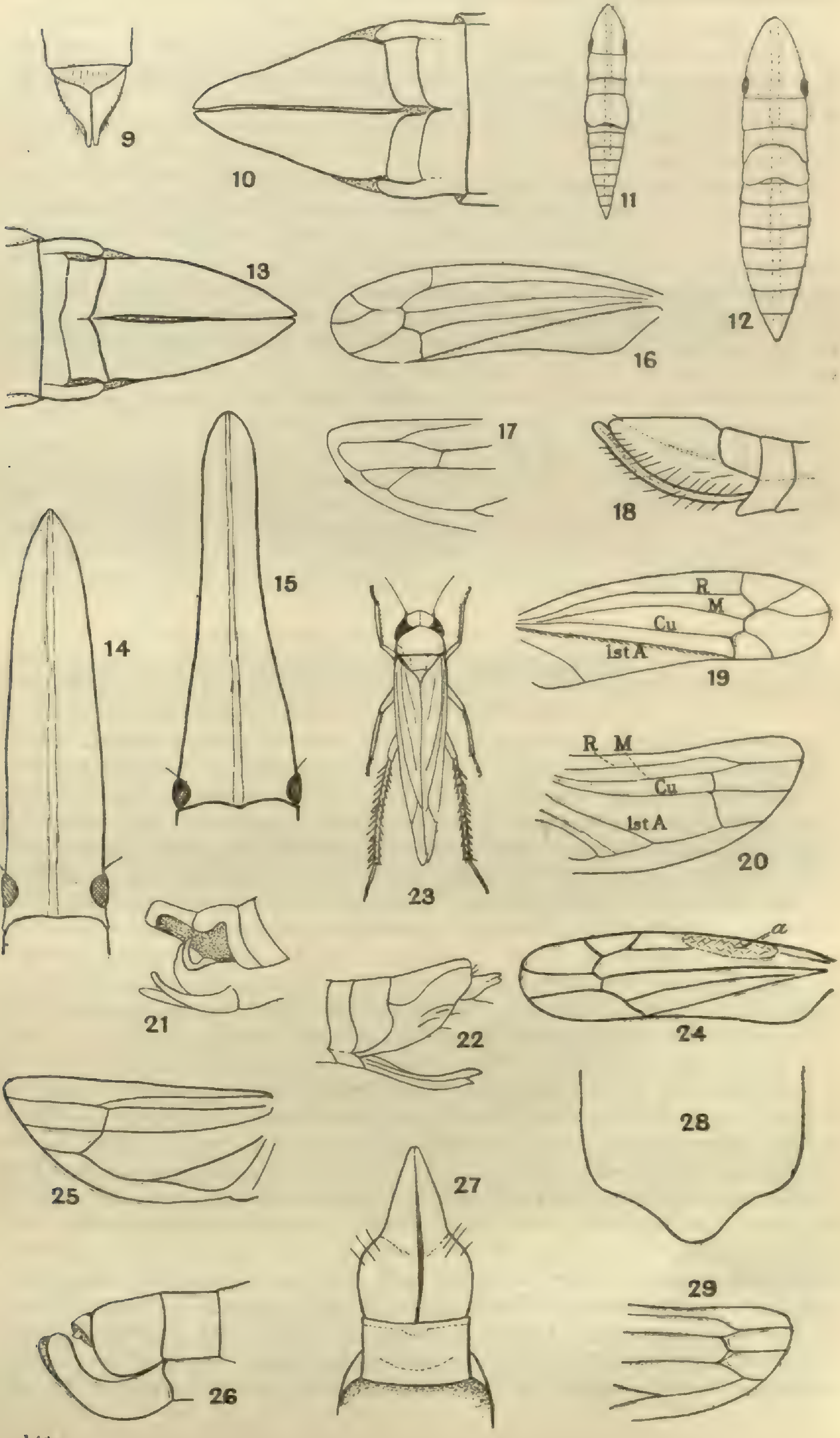
The jointed rush (*Leptocarpus simplex*) has smooth green or reddish internodes, while the fairly frequent nodes are surmounted and partly surrounded by rougher greyish or brownish sheaths. It is to these sheaths the leaf-hoppers bear such an extraordinary resemblance. The insect always rests with its long axis parallel to that of the stem—a position necessary for "purposes" of mimicry, but probably assumed for the sake of comfort.

Occasional examples are parasitized by large, long-legged scarlet mites with long hairs. In one case three of these mites were fastened tightly to the base of one of the tegmina, which, apparently as a result of their sucking, had curled up and twisted like the half of a dried pea-pod. More commonly only one mite is found, and that tucked beneath the tegmina, the abdomen of the *Cephalelus* being then often slightly deformed, but no other effects apparent.

The nymphs of *all* ages are found on the food-plant with the adults. They are almost uniform pale brown, with a very indistinct pallid median dorsal line, and a head much less produced than that of the adult. I have not yet succeeded in finding the eggs.

Holotype and allotype in Myers collection, Biology Laboratory.

FIG. 9.—*Paradorydium philpotti* n. sp.: male genitalia, ventral view.
FIG. 10.—*Cephalelus hudsoni* n. sp.: male genitalia, ventral view.
FIG. 11.—*C. hudsoni* n. sp.: nymph, early instar; legs omitted.
FIG. 12.—*C. hudsoni* n. sp.: nymph, late instar.
FIG. 13.—*C. leptocarpi* n. sp.: male genitalia, ventral view
FIG. 14.—*C. hudsoni* n. sp.: head of female.
FIG. 15.—*C. leptocarpi* n. sp.: head of female.
FIG. 16.—*Dikraneura maorica* n. sp.: tegmen.
FIG. 17.—*D. maorica* n. sp.: wing.
FIG. 18.—*D. maorica* n. sp.: female genitalia.
FIG. 19.—*Typhlocyba australis* (Frogg.): tegmen.
FIG. 20.—*T. australis* (Frogg.): wing.
FIG. 21.—*T. australis* (Frogg.): male genitalia.
FIG. 22.—*T. australis* (Frogg.): female genitalia.
FIG. 23.—*T. australis* (Frogg.): imago (after Froggatt).
FIG. 24.—*Erythroneura zealandica* n. sp.: tegmen. *a*, costal plaque.
FIG. 25.—*E. zealandica* n. sp.: wing.
FIG. 26.—*E. zealandica* n. sp.: male genitalia, lateral view.
FIG. 27.—*E. zealandica* n. sp.: male genitalia, ventral view.
FIG. 28.—*E. zealandica* n. sp.: female subgenital plate.
FIG. 29.—*E. zealandica* n. sp.: wing (venational aberration not present on opposite wing).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Cephalelus leptocarpi n. sp. (Figs. 13, 15.)

♂♀. Same colour and markings as *C. hudsoni* n. sp., from which it differs in its smaller size, genitalia of male (fig. 13), and, above all, in the *very distinctly spatulate head* (fig. 15). Examination of a large series of both species has shown these differences to be constant.

Length: Male, total length, 8·5–9 mm.; head, 2–2·5 mm.: female, 8·5–10 mm.; head, 3 mm.

Described from twenty males and twenty-two females.

Holotype (male) and allotype in Myers collection, Biology Laboratory.

There are two specimens in the Hutton collection at Canterbury Museum from Whangarei (no date), where I myself took the material on which I have founded the species. The locality was the edge of a mangrove-swamp, and the food-plant *Leptocarpus simplex*, as in the previous species. It is interesting that although there were acres of almost pure *Leptocarpus* association, yet this insect was found, after a large area had been fruitlessly swept with the net, rather plentifully on a patch not a yard square, and apparently nowhere else in the vicinity.

The nymphs, which are dark brown in colour, are found on the food-plant with the adults. The distinctly spatulate head is noticeable at a very early stage.

This species is parasitized by apparently the same red long-legged mite as *C. hudsoni* n. sp.

The sexes were present in approximately equal numbers. December–January.

Subfamily 3. TYPHLOCYBINAE.

Syn. Eupteryginae *auctt.*

Probably every one is vaguely familiar with the minute whitish active insects which leap vigorously in all directions whenever the grass of lawn or meadow or alpine slope is disturbed by one's passage. Their precipitate flight may even carry them into the picnicker's tea, whence I have occasionally rescued useful specimens. These extremely minute leaf-hoppers, the smallest and most delicate of the Cicadellidae, are members of the subfamily Typhlocybinae. Grass-land is by no means their only habitat; in fact, their distribution wherever vegetation occurs is so wide, and their numbers so great, that there can be few commoner insects in New Zealand. In spite of this fact, the Typhlocybinae have been so neglected that until 1906, when Kirkaldy described fourteen species from Australia, not a single species had been recorded from Australasia; and the same reproach holds in New Zealand to the present date.

As indicated above, the neglect the Typhlocybinae have suffered at the hands of collectors has been such that I have not seen a single specimen in any New Zealand collection other than my own. This paper consequently deals only with material of my own collecting, and its distributional records are, therefore, as inadequate as the area in which I have collected has been circumscribed. For the guidance of future collectors who may wish to gather in a portion of the harvest of new species which assuredly await description, a few notes on collecting and preserving these leaf-hoppers may be useful. Practically the only method of taking those species which occur on bushes and long herbage is that of beating and sweeping. A deep net should be used and the catch examined frequently, otherwise it is impossible to prevent the escape of some while others are

being taken from the net. The species frequenting ground-herbage and short grass are with difficulty obtained thus, and then only by very close sweeping. Such species apparently live very near the ground, well below the free tops of the plants which the sweeping-net reaches. The only certain way of securing these is by capturing them individually with a small net about 3 in. in diameter. This method, necessitating kneeling, as it does, has its disadvantages, but, on the other hand, much more can be observed of the habits of the insects than in the random processes of beating and sweeping. In swampy country, with pools of water, many leaf-hoppers are to be found hopping on the surface of the water, on to which they have come from their adjacent host-plants, and many more can be sent to join them by shaking and kicking the herbage surrounding the water, from which the insects are collected with comparative ease. It is of the utmost importance that records of the food-plants be kept wherever possible.

For killing Typhlocybines and all other leaf-hoppers a cyanide-bottle or small tube, with a smaller tube or quill through the cork, in coleopterist fashion, is most convenient. It is highly essential that the inside of the bottle be kept dry, otherwise the insects will stick to the sides and to one another and suffer irreparable damage. If the cyanide-bottle has been prepared by the plaster-of-paris method, practically no care will maintain a perfectly dry interior. Pieces of dry potassium cyanide should be placed in the bottom of a tube, covered by several layers of blotting-paper, and then by a tightly-fitting cork, slightly perforated to allow the fumes to pass. Above this cork, which should be forced tightly down on the cyanide, place a piece of blotting-paper and a little crumpled tissue-paper. Several such tubes should be at hand, and if they are kept only for leaf-hoppers no moisture will collect in them.

For permanent preservation Typhlocybines should be gummed *across* the apex of card triangles, so that the underside of at least the head and genitalia may be examined, or they may be pinned through the scutellum with the finest pins used by micro-lepidopterists. For correct determination a large series is convenient, some of which should be mounted to display the tegmina and wings. On collecting-excursions of long duration they may be kept indefinitely in small screws of tissue-paper; but specimens to be mounted with extended wings must be set as soon as possible after death.

Except in the case of such economically important species as the apple leaf-hopper (*Empoasca mali* Le Baron), the rose leaf-hopper (*Typhlocyba rosae* Linn.) and the grape leaf-hopper (*Erythroneura comes* Say) the biology of the Typhlocybinae is but little known. The first of the above-mentioned species, the American apple leaf-hopper, not only inflicts serious damage on the foliage of apple, potato, bean, and lucerne, but also actually transmits two diseases, fireblight (*Bacillus amylovorus*) of pomaceous fruit-trees and hopper-burn of potatoes. Even in the cold winters of North America, specimens of the apple leaf-hopper frequently winter in the adult state. In New Zealand, specimens of *Erythroneura zealandica* n. sp. have been taken after midwinter, and, considering our milder climate, it is quite possible that many of our species are carried over the winter as imagines. The evergreen nature of our bush would help such species as find their host-plant there.

In New Zealand we have one species ranking as a serious apple pest, and probably as a carrier of fireblight; another of very wide occurrence

on a variety of field-crops and pasture-plants, but not yet convicted of serious damage; and a third species, an endemic one, inflicting the same damage on *Coprosma grandifolia* as the introduced *Typhlocyba australis* (Frogg.) on apple.

The Typhlocybinae are among those leaf-hoppers parasitized by minute wasps of the family Dryinidae. None, however, have yet been successfully reared from New Zealand species, nor have I found affected leaf-hoppers very numerous. Bird enemies probably account for very few, although in America these small leaf-hoppers are said to form a certain proportion of the food of humming-birds. Finally, Mr. Muir informs me that egg parasites are generally common.

The structural characters of the Typhlocybinae render them probably the most homogeneous and easily recognized subfamily of the Cicadellidae. In the tegmen the three longitudinal veins of the corium—the radius, media, and cubitus—run without branching to the apical cells, so that *no ante-apical cells are formed.* The 1st A corresponds almost exactly with the claval suture (Cu_2 not present) and the third with the claval margin, leaving only a single vein on the disc of the clavus—a character shared (according to McAtee) by no other Auchenorrhyncha. The ocelli are almost always difficult to distinguish, and are often lacking. Long elliptical areas about the middle of each costa bear a thick circumscribed coating of a wax-like substance. The detachable pruinose flakes are known as the "costal plaques." Some species—*e.g.*, *Erythroneura cyathea* n. sp.—possess them well developed; but they are by no means a specific character, being subject to individual variation.

Important generic distinctions are found in the venation of tegmina and wings, the main characters being very constant; but the details vary with the individual. Good specific characters are found in the genitalia.

The Typhlocybinae are to be considered among the most highly evolved of the Cicadellidae, their specialization consisting in a simplified venation probably derived from a much more complex type.

The New Zealand species at present collected include six species in three genera. Of these six species, five are new, and one apparently introduced from Australia, although Mr. Muir informs me that it is by no means certainly endemic there. I am indebted to Mr. Muir for kindly reading the manuscript of this subfamily and for valuable advice and help.

I have followed McAtee in the generic nomenclature. *Typhlocyba* is often used by other authors where McAtee uses *Eupteryx*, of which *Typhlocyba* is in part a synonym. Under such a system my *Typhlocyba* would be *Empoa*.

Key to Genera of New Zealand Typhlocybinae.

1.	Wing with submarginal vein	*Dikraneura.*
	Wing without submarginal vein	2
2.	Second apical cell of tegmen triangular and stalked; fourth apical vein of tegmen curving, to end in *radial* margin	*Typhlocyba.*
	Second apical cell of tegmen nearly oblong, based on cross-vein; fourth apical vein of tegmen running parallel to radial margin and ending in *apical* margin	*Erythroneura.*

In connection with this key it should be noticed that, according to Osborn, Gillette, and Woodworth, all those species in which the wing has no submarginal vein and the first two veins unite before reaching the margin, so that only three veins attain the margin, fall into the genus *Typhlocyba* Germar. Only the African genus *Molopopterus* Jacobi, which is easily distinguished by other characters, is excepted.

The synonymy of *Typhlocyba* Germar would, according to these authors, stand as follows : *Erythroneura* Fitch, *Idia* Fieber, *Zygina* Fieber, *Anomia* Fieber, *Aidola* Melichar, *Empoa* Fitch (part), *Zyginella* Low. The splitting of this unweildy genus becomes, therefore, an obvious desideratum. and Kirkaldy and McAtee proposed to effect this on the old distinction, denounced by Woodworth as untrustworthy and inconstant, that in *Typhlocyba* (*sens. strict.* and as used by me) the fourth apical vein of tegmen curves to the radial margin, and the second apical cell is triangular and usually stalked, while in *Erythroneura* (*sens. strict.*) the fourth apical vein of tegmen runs parallel to the radial margin and ends in the apical margin, the second apical cell being more or less oblong and based directly on the cross-vein. Examination of very large series of New Zealand specimens has shown this to be a perfectly constant character so far as our species are concerned, and it has consequently been adopted in this paper. The figures of *Typhlocyba* and *Erythroneura* venation will show this difference more clearly than a printed description. Should further study demonstrate instability in this venational character, all the species I have described under *Erythroneura* must be placed in *Typhlocyba*. which will then have the complete synonymy given above. In all the species of both genera which I have examined the male genitalia, and especially the aedeagus, differ fundamentally. and thus afford a sounder distinc ion between the two genera than the venation alone could supply. The figures will show this clearly.

Genus 1. DIKRANEURA Hardy.

An almost cosmopolitan genus.

Dikraneura maorica n. sp. (Figs. 16–18.)

♀. Vertex, pronotum, and scutellum sulphur-yellow. Tegmina paler. Eyes black. Wings hyaline, somewhat opalescent. Underside and legs uniform yellow. Claws black. Tarsi often green. Rostrum tipped with crimson. Vertex rather more than twice as wide as medianly long. Fore-border rounded. Pronotum rounded anteriorly ; posterior angles somewhat produced but truncate ; posterior border moderately excavated. Genitalia concolorous with rest of body, except ovipositor, which is shining brown.

Length (including, in this and subsequent species, the folded tegmina) : Female, 3 mm.

Male unknown.

This beautiful little species is near to *D. flavipennis* (Zett.), which it resembles also in habitat (among sedges in damp places). It is distinguished by the fore-border of vertex, which in our species is rounded instead of angular, and by the absence of black points on the hind tibiae.

Among carex and grass in bush-clearing (swamp-forest), Long Acre, Wanganui, December.

Described from nine females.

Holotype in Myers collection, Biology Laboratory.

Genus 2. TYPHLOCYBA Germar. (Figs. 19–23, 35, 36.)

Typhlocyba australis (Froggatt). Australian Apple Leaf-hopper.

Empoasca australis Frogg., *Agric. Gaz. N.S.W.*, vol. 29, p. 568, 1918.

♂ ♀. Vertex and pronotum bright sulphur-yellow ; eyes usually blackish. Scutellum bright yellow, often with deeper-yellow patch on each side of base. Tegmina of the same bright-yellow tint, membrane iridescent

and hyaline. Wings hyaline; underside uniform yellow. Frons yellow. Vertex approximately twice as broad as medianly long. Fore-border rounded. Pronotum trapeziform, rounded anteriorly and slightly excavated posteriorly. Scutellum slightly narrower at base than base of head including eyes. Ovipositor shining mahogany-brown.

Total length, 4 mm. (male and female).

November to March.

Nelson, Auckland, and Hawke's Bay orchard districts, where it inflicts considerable damage on the foliage of apple and hawthorn. This species is probably introduced from Australia, and must not be confused with the well-known *Empoasca mali* (Le Baron) of America, which has not yet been introduced, and from which it differs not only structurally but also biologically, in that the results of its attack are rusty spots and patches on both sides of young and old leaves, instead of a curling of the younger leaves only, as in the American species. Its method of attack is very similar to that of *Typhlocyba* (*Empoa*) *rosae* (Linn.), which it resembles in some other respects, but from which it is quite distinct.

Genus 3. Erythroneura Fitch.

Key to New Zealand Species.

1. Colour dark, with numerous markings	*E. ansonae.*
Colour pale and practically uniform	2
2. Colour bright golden-yellow	*E. kiekie.*
Colour pale-yellowish, greenish, or whitish	3
3. Under 3 mm. long. Colour green or greenish-yellow. Dorsal surface of abdomen black	*E. zealandica.*
Over 3 mm. long. Colour whitish. Dorsal surface of abdomen white	*E. cyathea.*

Erythroneura zealandica n. sp. (Figs. 24–29, 37, 39, 41, 42.)

Vertex dirty greenish-yellow, with sometimes an indistinct greyish smudge on each side. Eyes greyish-black or grey, edged with paler. Pronotum and scutellum yellowish-green, the latter sometimes with darker-coloured area on each side of base. Scutellum divided by transverse middle line into a plane anterior portion, with indications of three median longitudinal stripes, and an elevated posterior portion including the acute apex. *Dorsal surface of abdomen black*, showing through tegmina and wings. Tegmina yellow to yellowish-green. Membrane and wings hyaline. Underside uniform pale-yellowish, the tibial spines and tip of rostrum darker. Vertex about twice as wide as medianly long. Pronotum broadly rounded anteriorly and slightly excavated posteriorly, with a very faint and occasional indication of a median longitudinal keel. Base of scutellum about

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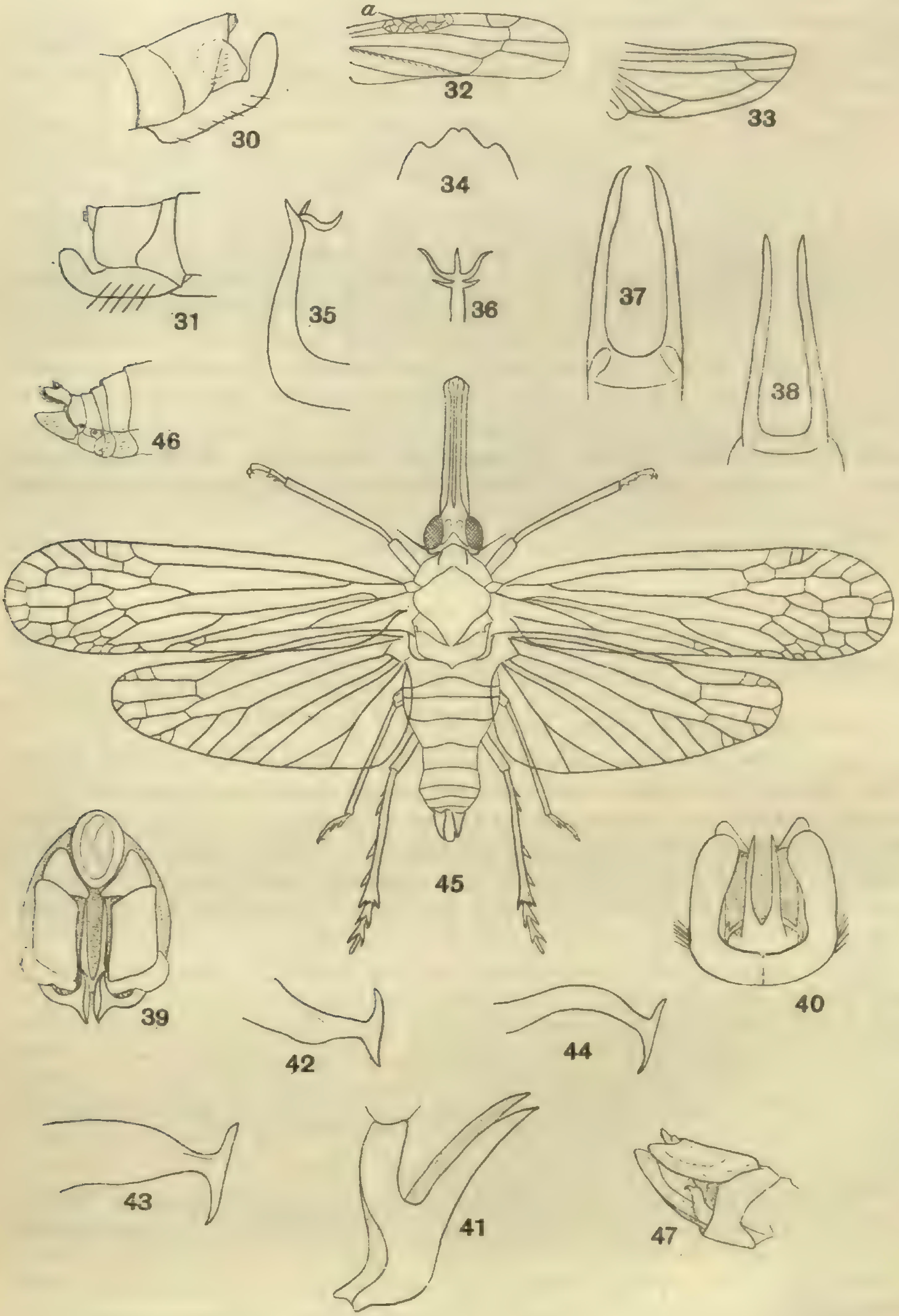
Fig. 30.—*Erythroneura kiekie* n. sp.: male genitalia.
Fig. 31.—*E. cyathea* n. sp.: male genitalia.
Fig. 32.—*E. cyathea* n. sp.: tegmen. *a*, costal plaque.
Fig. 33.—*E. cyathea* n. sp.: wing.
Fig. 34.—*E. ansonae* n. sp.: female subgenital plate.
Fig. 35.—*Typhlocyba australis* (Frogg.): aedeagus, lateral view (after Muir).
Fig. 36.—*T. australis* (Frogg.): apex of aedeagus (after Muir).
Fig. 37.—*Erythroneura zealandica* n. sp.: aedeagus, ventral view.
Fig. 38.—*E. cyathea* n. sp.: aedeagus, ventral view.
Fig. 39.—*E. zealandica* n. sp.: caudal view of pygophor (eighth sternite removed).
Fig. 40.—*E. kiekie* n. sp.: caudal view of pygophor; anal segment not shown.
Fig. 41.—*E. zealandica* n. sp.: aedeagus, lateral view.
Fig. 42.—*E. zealandica* n. sp.: male genital style.
Fig. 43.—*E. kiekie* n. sp.: male genital style.
Fig. 44.—*E. cyathea* n. sp.: male genital style.
Fig. 45.—*Thanatodictya tillyardi* n. sp.: male.
Fig. 46.—*T. tillyardi* n. sp.: lateral view of male genitalia.
Fig. 47.—*T. tillyardi* n. sp.: male pygophor.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as wide as base of vertex between eyes. Apex of scutellum acute. Male genitalia short and abrupt; claspers bent abruptly, tips almost reaching the dorsal line of abdomen in lateral view. Female genitalia—ovipositor short, tipped with fuscous, and furnished with seven or eight very stout short bristles. Ninth or last unmodified abdominal tergite abruptly truncate.

Total length, 2·7 mm. (male and female).

This is the common grass-frequenting species, found in large numbers in any grassy places, whether the grass be introduced pasturage or native tussock. It is also common in all stages on tauhinu, or cottonwood (*Cassinia leptophylla*). There is considerable colour-variation, those from Wanganui being yellowish, the common Wellington specimens greenish, and those taken on tauhinu in various localities of the Wellington district a peculiar greyish-green resembling that of the food-plant. I can find no accompanying structural differences. The various forms seem to grade into one another. A somewhat dilapidated female taken on mangrove at Whangarei appears to belong to this species. Typical specimens have been collected from manuka (*Leptospermum scoparium*). While making the above description wide enough to include all the forms here enumerated, I have retained the *Cassinia* forms as types.

Tararua Range, Wellington, 4,000–5,000 ft.; Wanganui; October to June.

Described from eighty-eight males and eighty-four females.

Holotype, allotype, and paratypes in Myers collection, Biology Laboratory.

Erythroneura kiekie n. sp. (Figs. 30, 40, 43.)

♂♀. Whole upper surface bright yellow, thoracic nota often orange. Eyes blackish (eye-colour is of little taxonomic value, as it may vary from whitish to black in the two eyes of the same individual). Tegmina yellow, the membranc a little paler, but not hyaline. Wings hyaline. Underside uniform pale yellow. Claws, except posterior ones, black. Ovipositor pale-brownish. Rostrum tipped with brownish. Upper surface of abdomen blackish. Vertex very broadly rounded anteriorly; not twice as wide as medianly long. Median longitudinal suture distinct. Pronotum rounded anteriorly, and considerably excavated posteriorly—the anterior portion paler and somewhat depressed, posterior half shining and darker yellow. Scutellum a little wider at base than base of vertex between eyes; transverse line about half-way, to which the sides gradually slope from base, beyond which transverse line (caudad) they rapidly narrow to the very acute and somewhat elevated apex.

Total length, 3·7 mm. (male and female).

This handsome species has been taken only on kiekie (*Freycinetia Banksii*), to which it may possibly be confined, and on which it occurs in considerable numbers.

York Bay, Day's Bay, Wellington; Whangarei; November to March.

Described from six males and six females.

Holotype, allotype, and paratypes in Myers collection, Biology Laboratory.

Erythroneura cyathea n. sp. (Figs. 31–33, 38, 44.)

♂♀. General colour pale yellowish- or greenish-white or practically colourless. Vertex pallid, tumid, produced, *punctate*, with occasionally two brownish patches varying from faint smudges to distinct spots. Eyes variegate. Pronotum with an anterior smooth, collar-like portion;

remainder finely transversely striate. Humeral angles produced, truncate, covering base of tegmina. Pronotum and tegmina very pale yellowish- or greenish-white or practically colourless. Pronotum *narrowly* rounded anteriorly, and very slightly excavated posteriorly. Wings milky. Base of scutellum considerably wider than posterior border of vertex. Scutellum with depressed anterior portion and slightly elevated acute apex. Triangular area on each side of base of scutellum often brownish. Under-surface pale creamy-white. Claws fuscous. Frons very tumid, with dull frosted surface. Genitalia of both sexes pale. Upper surface of abdomen white.

Total length, 3·4–4 mm. (male and female).

In one well-marked variety (No. 175) the colour is a somewhat brighter yellowish, and the hind border of pronotum, disc of scutellum, extreme edge of radial margin of tegmina, and to a less extent the membrane of tegmina are suffused with fuscous.

In a second variety (No. 185, one specimen) the brown colour is confined to the two basal triangular spots of the scutellum and to its sides, forming a very distinct dorsal V. As I can find no accompanying structural peculiarities, and as the faint brown markings sometimes present in the more typical specimens vary greatly in intensity, I am constrained to regard this as nothing more than a colour variety comparable to those of the common Cercopid *Philaenus trimaculatus* (Walker).

This variable and common species occurs among mixed undergrowth in ordinary rain-forest. With specimens collected by beating and sweeping it is difficult to be sure of the food-plants, but one is the tree-fern *Cyathea dealbata*, and another, on which all stages can be collected, is *Coprosma grandifolia*. Specimens from the tree-ferns are uniformly and constantly more whitish, and the types have been selected from these.

Tararua Range, Wellington district, 2,000–3,000 ft., November to June.

Described from twenty-six males and forty females.

Holotype, allotype, and paratypes in Myers collection, Biology Laboratory.

Erythroneura ansonae n. sp. (Fig. 34.)

♀. General colour yellowish marked and suffused with greenish and olivaceous. Vertex fairly considerably produced, about twice as wide as medianly long. Eyes black, edged with yellow. Median suture of vertex distinct, with or without obscure dusky blotch on each side. Pronotum—disc dark olive, anterior and lateral borders pale yellow. Just caudad of anterior yellow edge the olive area is edged with blackish; a few other small irregular black marks. Pronotum sloping gradually from rounded anterior point to posterior border, which is considerably but gradually excavated. Scutellum at base much wider than base of vertex, but not quite so wide as eyes. Transverse line at ½ divides the olivaceous anterior portion, with its two shining brown basal triangles, from the elevated bright-yellow apex. Lateral angles of scutellum paler. Dorsal surface of abdomen dark, showing through closed tegmina and wings. Tegmina semitransparent, olivaceous; membrane infuscated. Ventral surface olivaceous or stone-coloured. Rostrum tipped with reddish-brown. Leg-spines darker. Ovipositor brownish, with a row of short stout bristles along each side. *Subgenital plate notched at tip* (fig. 34), a very distinct character. Frons and clypeus deep dirty-yellow. Clypeus with some indications of transverse rugosities. Genae darker.

Total length (female), 3·5–3·7 mm. Male unknown.

The markings superficially resemble those described for *E.* (*Zygina*) *parvula* (Boh.), but are much less clearly defined. A comparison of the

two insects shows, moreover, that the whole habitus of the present species is different, the tegmina particularly being one and a half times as long as those of *E. parvula*.

Damp grassy and sedgy clearings in rain-forest, Wellington, Wanganui; December–April.

I dedicate this distinct and handsome species to Mrs. H. J. D. Stowe (*née* Anson), whose co-operation in collecting has been invaluable.

Described from two females.

Holotype in Myers collection, Biology Laboratory.

II. FULGOROIDEA (Plant-hoppers).

Some sixteen species of this interesting superfamily have now been described from New Zealand. This number probably represents a mere fraction of the total. It includes several introduced forms from Australia, notably *Siphanta acuta* Walker, *Scolypopa australis* Walker (common in tremendous numbers on a great variety of plants in the Waikato and Auckland districts), and *Sephena cinerea* Kirkaldy (also common in the Auckland Province). The latter has been proved to carry fireblight (*Bacillus amylovorus*) of apple-trees, Mr. R. Waters, Bacteriologist of the Biology Division of the Department of Agriculture, having artificially induced the disease by means of cultures from infected leaf-hoppers. An effort was made to ascertain whether the bacilli were transferred by the sucking of the plant-hopper, and with this end in view, at Dr. Tillyard's suggestion, cultures were prepared from the salivary glands of this insect, but were unsuccessful owing to the presence in overwhelming numbers of other bacteria.

A considerable number of endemic Fulgoroids now await description. They will not be published until a thorough study of the genitalia has been made. Mr. F. Muir, whose assistance in this superfamily has been especially valuable, is examining next year some of Walker's Cixiid types in the British Museum, so that a complete revision must await the results of this examination. In the meantime I am describing here a new and striking species which is the unique representative of its family in New Zealand, and is not therefore likely to be confused with any other species.

Family DICTYOPHORIDAE.

Well represented in the Australian and Oriental regions.

Genus Thanatodictya Kirkaldy.

Bull. 1, Div. Ent., H.S.P.A. Expt. Sta., p. 392, 1906.

A typically Australian genus.

Head very elongate, narrow, porrect. Vertex bordered on each side by a keel. Tegmina hyaline: apical third subreticulate. Legs simple; posterior tibiae four-spined. Vertex nodulose at base, and stigma dark (this last sentence characterizes the subgenus *Niculda* Kirk.).

Thanatodictya tillyardi n. sp. (Figs. 45–47.)

♂. General colour fulvous clouded with fuscous. Vertex bright yellowish-brown, except nodulosities at base, which are darker. Immediately anterior to these, vertex is finely transversely striate; a dark-brown stripe between longitudinal ridges of vertex. Pronotum concolorous with

base of vertex; *median pronotal keel ivory-white.* A median ivory-white stripe on mesonotum expanding caudad, and ending in bluish-white posterior angle of scutellum. Mesonotum darker brown, with longitudinal keel on each side. Basal abdominal terga marked heavily with fuscous; remainder of dorsal surface of abdomen rich brown clouded with fuscous, segmental margins relieved sparingly and medianly with pallid. Tegmina and wings hyaline, colourless. Veins brown, darker distally. Stigma blackish, with normally two internal transverse veins; but the right tegmen of one specimen has only one transverse vein in stigma. A blackish smudge extends from apex of tegmen to apex of suture, and farther as an ill-defined line along dorsum of tegmen. Head slightly ascending; about as long as remainder of body. Legs longitudinally angular; stramineous striped with piceous; sparingly setose. Ocelli clear yellow ringed with scarlet. One specimen is much paler than the other.

Total length (male), 7–8 mm.; tegmen, 6–7 mm.

By its nodulose base to vertex it belongs to subgenus *Niculda* Kirkaldy. In its somewhat ascending head it resembles *T.* (*Niculda*) *anadyomene* Kirkaldy; but differs in its larger size and in the presence of only two transverse veins in the stigma of tegmen, both well marked.

Holotype (male), Myers collection, Biology Laboratory; paratype (male), Tillyard collection, Cawthron Institute, Nelson.

Described from two males taken by Dr. R. J. Tillyard at a height of 3,000 ft on the Dun Mountain, Nelson, in February. I have much pleasure in naming it after the discoverer.

Since the above was written Mr. A. Philpott and M. André Tounoir have taken the species in considerable numbers by sweeping bracken-fern (*Pteridium esculentum*) near the same locality. Some of the specimens show a strong and beautiful green suffusion.

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Art. 31.—*New Species of New Zealand Cicadidae.*

By J. G. Myers, F.E.S., Biology Division, Department of Agriculture.

[*Read before the Wellington Philosophical Society, 25th October, 1921; received by Editor, 31st December, 1921; issued separately, 30th April, 1923.*]

A new genus is added to the New Zealand fauna by the discovery of two species of *Pauropsalta* Goding and Froggatt. The two genera of New Zealand Cicadidae may readily be distinguished as follows:—

Wings with six apical cells .. *Melampsalta* Amyot.
Wings with five apical cells .. *Pauropsalta* God. & Frogg.

Melampsalta campbelli n. sp.

♀. Bright olive-green marked with black and pinkish-red. Vertex olive-green suffused with pink; covered with black and metallic-gold hairs. Ocelli greenish-amber, surrounded by a black patch sending a black line latero-caudad to the pronotum. Eyes overlapping the pronotum caudad, olive-green with an intricate foliaceous pattern in black. Antennae black. Frons and clypeus reddish-olive with a dark median area from which extend laterad seven or eight transverse piceous ridges. Rostrum reddish-amber, extending to about middle coxae. Coxae red, with bold shining black markings. Pronotum glabrous except for a very few scattered short black or shining gold hairs; a rectangular black spot on middle of posterior border; two irregular oblique lines laterad, black and impressed as though burnt; posterior border produced slightly and flattened, forming a slight rim which is pink, and, transversely, irregularly striate. Mesonotum with a longitudinal triangular brownish-black mark on each side, extending from pronotum nearly to posterior border; two shorter triangular blackish spots between these; an impressed black spot at each of the two anterior corners of the cruciform elevation. Cruciform elevation brownish-pink, clothed in the lateral angles with glistening silver hair. Remainder of mesonotum olive-green and clothed as pronotum. Abdominal terga jet-black with segmental margins olive-green. The green segmental margins increase in width caudad until they occupy more than half the visible portion of the tergum. Clothing as on the nota, but with a patch of silver hairs on the middle of each segmental margin, forming an irregular longitudinal dorsal streak. Ultimate tergum with a deep black line on each side; remainder thereof and penultimate tergum red. Abdomen ventrally pinkish-olive with a faint longitudinal dark line. Ovipositor shining fuscous. Legs pinkish-yellow, anterior ones with black markings. Posterior tibiae with five long spines (exclusive of apical coronet)—three inner and two outer. Tarsi pale pink. Tegmina and wings hyaline. Veins—proximal half magenta, distal half fuscous. Small portion of anal area of wing opaque china-white. Wings very short in proportion to body.

Length of body, 16 mm.; tegmen, 14 mm.

This, our most brilliantly coloured cicada, is so distinct that I can single out none of the above characters for special emphasis. I have much pleasure in dedicating it to the discoverer, Mr. J. W. Campbell, who took the two female specimens at Otira on the 10th January, 1920.

Type ♀, and ♀ paratype, Myers collection, Wellington. Male unknown.

Pauropsalta lindsayi n. sp.

♂. Dull black, densely covered with a short closely appressed golden pubescence, causing it to assume a dusty-yellowish appearance. Vertex with a very few long black hairs in addition to the universal gold pubescence. Ocelli toffee-coloured. Eyes dull olive with a few blackish markings. Antennae dull black. Face with fine black transverse ridges. Ventral surface pale, dirty olivaceous with silvery pubescence and a few indistinct darker markings. Rostrum reaching middle coxae. Pronotum as vertex, but with two deeply impressed oblique black lines on each side. Between the black lines on each side are a few irregular black ridges. Mesonotum as pronotum. Cruciform elevation normal, dull olive, but with the same universal gold pubescence. Abdomen as nota. Segmental margins very narrowly yellow—too narrowly to be perceptible with the naked eye. Tymbals white (as seen from above). Genitalia very distinct. Sternal plate projects well beyond everything else in dorsal view. Ventrally this sclerite has a strong keel and is altogether boat-shaped. Legs dull greyish-yellow marked with darker. Posterior tibiae with five long spines (exclusive of apical coronet). Tegmina and wings hyaline. Veins pale brown.

Length of body, 12·5 mm.; tegmen, 12 mm.

The single known specimen of this, our smallest cicada, was discovered at Mount Grey, Canterbury, in November, 1917, by Mr. C. Lindsay, to whom I dedicate it with much pleasure. The insect was found on a clay surface where its colouring rendered detection extremely difficult.

Type ♂, Myers collection, Wellington.

NOTE.—Since the above was written Mr. Lindsay has given me another male of *P. lindsayi* and shown me a third, both collected by himself and his brother, Mr. S. Lindsay.

Pauropsalta maorica n. sp.

♀. Brownish-pink marked with black; the abdomen almost wholly black. Vertex black, anteriorly and laterad terra-cotta; sloping abruptly ventrad in front of the posterior ocelli; clothed with sparse golden pubescence and long black hairs. Ocelli pinkish-amber. Eyes overlapping the pronotum caudad, greyish-olive marked with castaneous. Antennae black. Frons reddish with seven black wavy transverse ridges. Rostrum stramineous, darkening distally and reaching to middle coxae. Genae densely clothed with long white hairs. Coxae reddish with black markings. Pronotum clothed, especially laterally, with sparse shining golden pubescence. A triangular spot on fore-border, an irregular median spot on posterior border, and two oblique impressed lines on each side, black. Remainder of pronotum greenish-pink. Mesonotum black, with very sparse golden pubescence. A trapezoidal brownish-pink spot on each side of middle. Cruciform elevation brownish-pink. Abdomen dull black, almost glabrous; the segmental margins of the posterior five or six terga reddish. Penultimate and ultimate segments very broadly edged with red, forming a red cincture and a red tip to the abdomen. Ovipositor *not* projecting beyond the outline of the abdomen. Ventral surface pale-reddish with pallid-yellowish segmental margins. Ovipositor darker, with numerous black hairs. Legs reddish, the anterior femora with fuscous streaks. Posterior tibiae with five long spines (exclusive of apical coronet)—three inner and two outer. Tegmina and wings hyaline. Costa red. Veins brownish-pink, darkening distally.

Length of body, 13 mm.; tegmen, 13·5 mm.

One female of this very distinct species taken at Nelson, 29th December, 1920, by Mr. A. Philpott, of the Cawthron Institute.

Art. 32.—*A New Tachinid Genus and Two New Species.*

By David Miller, Government Entomologist.

[*Read before the Wellington Philosophical Society, 25th October, 1921; received by Editor, 31st December, 1921; issued separately, 12th May, 1923.*]

Plate 37.

Amongst a large collection of Diptera recently presented to me by Mr. J. W. Campbell, of Christchurch, is a most interesting new species of Tachinid, which I describe below in a new genus under the name of *Campbellia campbelli*. Not only has Mr. Campbell secured large numbers of valuable Diptera, but he is also an accomplished observer of the structure and habits of these insects, as is amply shown in his recent work on the adult and pre-adult stages of the Blepharoceridae.*

In 1911 Mr. E. H. Atkinson captured a second species, which was sent to the British Museum, and through the courtesy of Mr. F. W. Edwards the specimen has been submitted to me, and is herewith recorded under the specific name of *cockaynei* n. sp., named after Mr. A. H. Cockayne, Government Biologist.

The extraordinary wing-development in these insects also occurs, only to a much greater extent, in the New Zealand Anthomyid *Exsul singularis* Hutton. A tendency to this development to a less extent occurs in several other species of mountain Diptera.

Subfamily GYMNOSOMINAE.

Genus Campbellia n. g.

Wing very broad, more than half as long as broad, the proximal half of posterior margin parallel to costa, distal part abruptly ascending to apex; apical cell closed and petiolate; third vein meeting costa very slightly below apex of wing; last section of fourth vein abruptly but evenly rounded upward to meet the third at right angle; posterior cross-vein about one and a third times its own length from the small cross-vein which is a little beyond the middle of the discal cell; first vein meeting costa almost immediately above small cross-vein; veins bare, stoutly developed; no sign of a costal spine.

Head much broader than high; eyes bare, dichoptic in male but convergent at ocellar triangle, extending below vibrissal angles, which are well above oral margin; the latter produced forward snout-like. Antennae well separated basally, extending close to forward curvature of face; first joint very short, third short and rather oval, a little more than one and a half the length of the second; arista pubescent, stout, three-jointed, first two joints short. Facialia bare, a few short weak bristles above vibrissae, frontal bristles weak and short, extending to base of second antennal joint; otherwise parafrontals bare; post-orbital bristles weak, not extending below middle of posterior orbits. Proboscis rather slender, elongate; palpi well developed, slender but swollen apically.

* *Trans. N.Z. Inst.*, vol. 53, pp. 258–88, 1921.

Thorax quadrate, scutellum narrow and broad; metanotum conspicuous behind scutellum; few outstanding chaetae, spatulate spines on wing costa at articulation and on meso- and noto-pleurae being unique (at least in male).

Legs stout and bristly; posterior tibiae with row of strong spines, becoming shorter basally and not reaching beyond middle, on outside of joint; protarsus not quite half length of whole tarsus; claws large; pulvilli large and narrow.

Abdomen (in male) transversely rugose, broader than thorax, broadly ovate, flattened; four visible segments, the first, second, and third of equal length, the fourth one and a half as long as preceding. Genitalia more or less prominent, curved beneath fourth segment. No abdominal chaetae, but among vestiture are distinct marginal bristles on third segment and lateral ones on third and fourth segments.

TABLE OF SPECIES.

Abdomen tawny, but fuscous apically; scutellum black, with a golden apex .. .. *campbelli* n. sp.
Abdomen deep purplish-blue on first two segments, the remainder rather cupreous and dusted with brownish pollen; scutellum unicolorous, bronzy-black .. .. *cockaynei* n. sp.

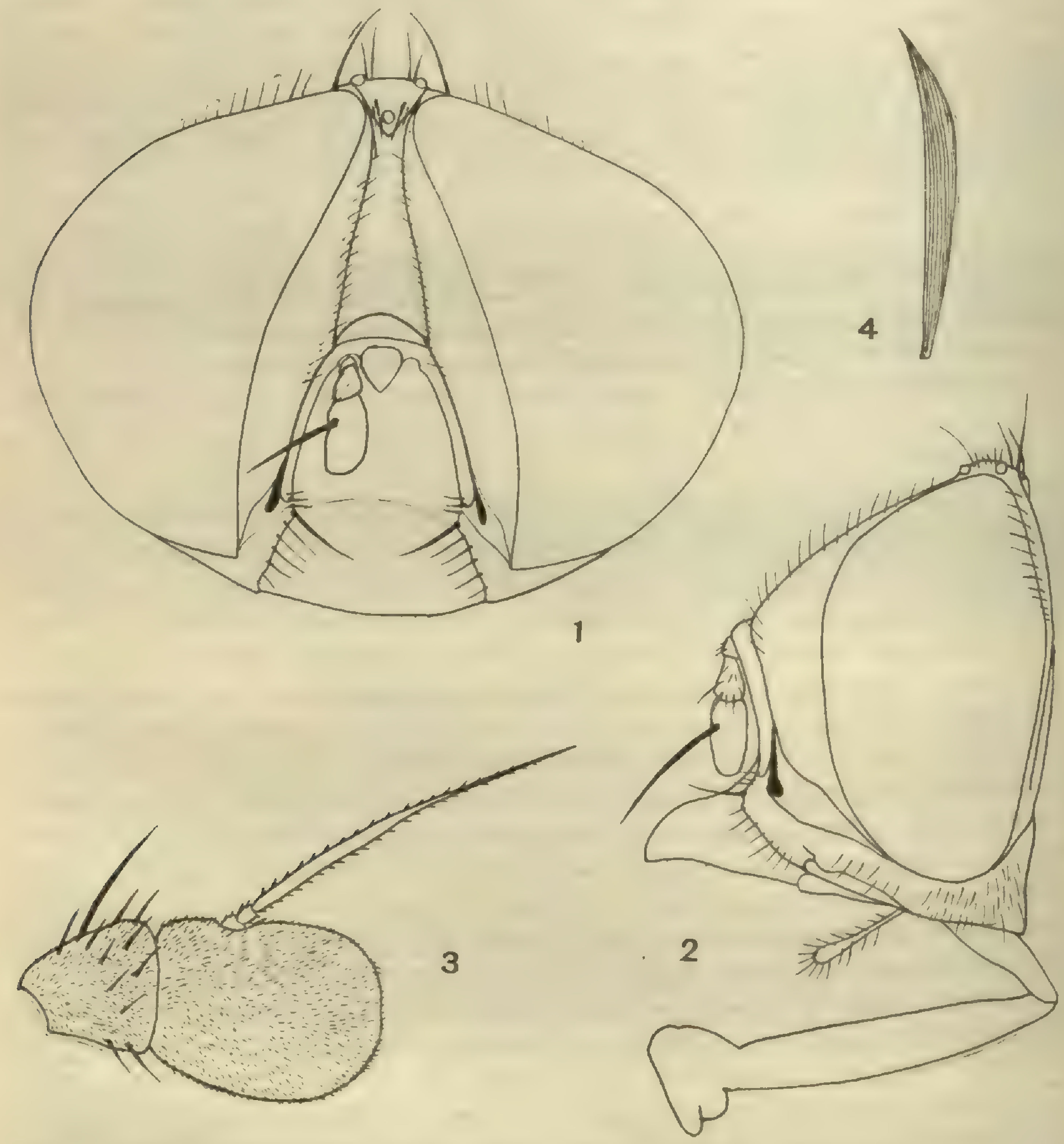
C. campbelli n. sp.

♂. Ptilinal suture (fig. 1) rather narrower above but evenly rounded, its termini situated in line with vibrissal angles well above line of lower eye-margins. Facial plate without carina, broad, concave, black, with cinereous tomentum, each side abruptly produced on to facialia and forward below to broad and prominent tawny epistome, which is minutely tomentose. Facialia prominent, black, bare except for a few short bristles just before vibrissae, which are large and widely separated, and situated well above oral margin. Peristomalia ascending, black, but with golden or whitish down and strong marginal bristles, behind which are a few short weaker ones. Oral cavity very large, elongate and rectangular; proboscis long and slender, rigid, geniculated, brownish in colour, the labella small; palpi slender, elongate, clavate, orange-red in colour. Lower margin of head longer than longitudinal axis at antennae; head, in profile, produced abruptly forward at oral margin, which is ascending (fig. 2).

Antennae (fig. 3) black, with a greyish reflection, comparatively short, extending to produced epistome; inserted above middle line of head and eye; broadly separated at insertion by globular projection of the shiny black lunula. Second joint normal, clothed with short greyish pubescence and short black bristles, a large conspicuous one above; third joint orbicular and clothed with minute greyish pubescence; arista stout, tapering to a point, longer than third joint, black, with stiff pubescence, three-jointed, the first very short, second a little longer.

Eyes bare, convergent in front of ocellar triangle and reaching well toward oral margin below line of vibrissal angles (fig. 1). Vertex narrow, space between eyes being occupied mostly by vertical triangle. Chaetotaxy of head consisting of delicate bristles; inner vertical bristles longer than others, reclinate and convergent; outer verticals absent; postorbitals extending almost to inner verticles and not reaching to halfway along orbits, but merging into and ending in very short bristles; a pair of well-separated post-verticals.

Front dull black in colour, but brownish in some lights; depressed throughout its length in the form of a shallow V-shaped depression; broad at antennae but narrowing abruptly to vertical triangle; deeply notched behind antennae, and between this and lunula is a deep, crescentic, black depression. Vertical triangle large and broadly triangular, black in colour, black ocelli prominent and well separated. Ocellar bristles delicate, convergent, proclinate; post-ocellars delicate; to each



Campbellia campbelli n. sp.

Fig. 1.—Ptilinal suture, &c. **Fig. 3.—Antenna.**
Fig. 2.—Profile of head. **Fig. 4.—Bristle of mesopleurae.**

side of ocellars is a short delicate bristle, while between ocellars post-ocellars are brownish hair-like bristles; pre-ocellars absent. Parafrontal areas black in ground-colour, but altogether silvery in some lights: projecting above plane of eye and front, demarcation being abrupt; transversely rugose between front and eye, much narrowed at vertex, broad at antennae, below which they descend along ptilinal suture to run abruptly to a point on orbits in line with vibrissal angles; depressed between ptilinal suture and orbits Frontal bristles in two rows descending

a little below antennae, otherwise parafrontals are bare. Parafacials without bristles; restricted to narrow area extending from terminii of ptilinal suture to a point on orbits; black but with golden to greyish pubescence around ptilinal terminii. Orbits sinuated to point on parafrontals below antennae. Cheeks silvery-white and clothed with delicate white hairs; narrow below parafacials but broadening below eyes and extending upwards on to occiput. Occiput black in ground-colour but with silvery grey tomentum; concave; bare but for a few delicate hairs and some short delicate bristles, into which merge orbital bristles from above; orbital area broad.

Thorax quadrate, black in ground-colour, dorsum dusted with silvery and golden pollen; a shiny black, broad area on each side extending from angles of transverse suture to alar calli. Scutellum narrow but broad; black but golden-yellow across apex, where are three deeper yellow spots, a narrow longitudinal median one and an oval one on each side. Metanotum conspicuous, developed as in nemocera; black, cinereous in some lights, bare. Sternopleurae clothed with delicate black bristles, among which are stronger ones above, there being in particular a large very strong spine near upper posterior angle. Hypopleural bristles consisting of a vertical row of strong bristles and a pair of smaller ones at upper posterior angle. Mesopleurae clothed with numerous large black bristles, many of which are spatulate in shape (fig. 4); they are arranged over upper part of mesopleurae, but extend below along posterior margin. Pteropleurae with a clump of large bristles above and a single spine below. Notopleural bristles consisting of a dense clump of black spatulate spines, there being also a large pointed spine among a few delicate bristles in front. Humeral bristles consisting above of a large stout spine, a long delicate bristle strongly recurved distally, some short delicate black bristles and a few golden ones; below is a clump of golden bristles and spatulate spines. Post-humerals consisting of some small black bristles, from among which projects a larger distinct one. The dorsum is uniformly clothed with short delicate bristles, among which the following may be seen with difficulty: a pair of presuturals; two pairs of dorsocentrals, near scutellar suture; one pair of acrostichals, near scutellar suture. A conspicuous pair of post-alars, large spine on alar angle outstanding. Scutellum clothed with delicate bristles, apical margin bare.

Wings (Plate 37, fig. 1) tawny at base, anterior portion clouded with brown, apex and remainder clear; veins tawny at base but otherwise blackish-brown; lower squamae large, rather hood-like, brownish, translucent, surface punctured; upper squamae brownish on one half, whitish on other, much smaller than lower squamae and fringed with long golden hairs. Petiole of apical cell about one and a half length of small cross-vein; a short blunt stump from fourth vein projecting into discal cell on distal side of small cross-vein; posterior cross-vein slightly sinuate; first vein very broad distally; halteres tawny and mushroom-shaped.

Legs stout and bristly; posterior femora laterally flattened, golden-yellow except for the blackish-brown apical third; clothed with numerous golden hair-like bristles basally and strong black bristles above, fewer below; three pre-apical bristles below to the outside. Middle femora blackish-brown but golden-yellow on basal third, anterior femora blackish-brown dusted with greyish pollen above and basally. Tibiae blackish-brown, each with a ridge on which is a row of short spines down outside, more distinct on posterior tibiae, which have a well-marked ridge running

down outer surface but ending before apex; on inside of this ridge proximally are three delicate bristles, and opposite these, on outside, is a row of five strong spines, being smaller to the base but not extending half-way down the joint. On side of tibia, almost in line with third most distal spine, is a distinct spatulate bristle. On upper side is a delicate pre-apical bristle, and below a stout apical one. Middle tibiae with stout apical spine below and delicate pre-apical one above; towards centre, but more distally, is a stout bristle toward lower side. Anterior tibiae with delicate apical bristles below and a pre-apical one above.

Tarsi normal in shape, bristly, blackish-brown; the protarsi pale brown, not quite half length of whole tarsi. Onychotarsi longer than preceding joint and with pair of delicate elongate bristles above; claws large, black; pulvilli large, narrow, pale brown.

Abdomen broadly ovate, flattened, four visible segments transversely rugose; tawny, apical segment fuscous in middle and apex, with greyish pollen; posterior margin of each segment darker. Dorsal plates curved on to ventral surface; ventral plate of first segment large, extending to margin of dorsal plate; ventral plates of other segments small, that of the fourth deeply notched on posterior margin to receive globular end of the black genitalia which are curved beneath apex of abdomen; ventral membrane conspicuous.

Abdomen diaphanous, dusted with yellowish-white pollen on each side of third and fourth segments; a blackish elongate spot on each side of centre margin of first segment. Surface of each segment sparsely clothed with short delicate bristles, being denser along sides. Distinct marginal bristles on third segment, and distinct bristles on each side of third and fourth segment.

♂. Length, 7·5 mm.

Genotype: No. 1259, D. M.

Habitat.—Blackball. Captured by Mr. J. W. Campbell; a single specimen.

C. cockaynei n. sp. (Plate 37, fig. 2.)

♂. Palpi tawny; front velvet-black and longitudinally striated. Dorsum of thorax shiny, rather blue-black; a golden tomentose area between scutellar and transverse sutures; dorsum margined with silvery tomentum, giving a striped appearance to thorax; three areas of silvery tomentum in front of transverse suture, arranged indistinctly as three short stripes, central one broadest; in side lights these merge to form a broad area continuous with posterior golden area. Pleurae black but with silvery to brownish tomentum in continuation with that margining dorsum; metanotum clothed with brownish tomentum. Petiole of apical cell about twice as long as small cross-vein. Legs blackish, anterior femora silvery and posterior somewhat tawny at base; posterior tibiae, protarsi, and epitarsi with golden hair along inner side. Abdomen deep purplish-blue, but the two apical segments rather cupreous in most lights; brownish pollen at posterior angles of second segment, along sides of third segment, and over most of apical. Genitalia prominent, projecting knob-like beneath apex of abdomen.

♂. Length, 7 mm.

Holotype in British Museum.

Habitat.—Day's Bay, Wellington Only one specimen, captured by Mr. E. H. Atkinson on flowering veronica.

Fig. 1.—Wing of *Campbellia campbelli* n. sp. × 8.
Fig. 2.—*Campbellia cockaynei* n. sp. × 4.

ART. 33.—*Material for a Monograph on the Diptera Fauna of New Zealand: Part III—Family Empididae.**

By DAVID MILLER, Government Entomologist.

[*Read before the Wellington Philosophical Society, 25th October, 1921; received by Editor, 31st December, 1921; issued separately, 12th May, 1923.*]

ALTHOUGH the present work deals with twenty-three species of Empididae, considerably more exist in New Zealand; many more have already come into my possession, but too late, unfortunately, to be included herein. For several of these I am indebted to Mr. J. W. Campbell, of Christchurch; my thanks are due also to Mr. G. E. Archey for the loan (through Mr. Speight, the Curator) of Hutton's types from the Canterbury Museum.

The Empididae may be characterized as follows: Head more or less spherical, but occasionally higher and narrower, or flattened from above and below. The occiput is usually convex, but sometimes concave in the middle; in some cases it encroaches considerably over the top of the head, the ocellar triangle being then situated well forward and the front shortened; there are three ocelli. The eyes, which occupy most of the head, are hairy or bare, deeply or slightly emarginate at the antennae, partially or wholly holoptic, or broadly or narrowly dichoptic on the front or face in the male or in both sexes; when holoptic the upper facets may be larger than the lower; the posterior eye-margin may be concave or convex. The front may be broad or narrow, practically absent, short or long, horizontal or more or less vertical. The antennae are closely approximated at the base and inserted about the middle head-height or a little above or below; the first two joints are short or the first somewhat lengthened; the third joint is pointed apically, but may be short and more or less oval, or elongate and clavate; it terminates in a one- or two-jointed style, which is either shorter or as long as the third joint and more or less stout, sometimes ending in a short distinct process, or is long and bristle-like. The face varies in shape according to the proximity of the eyes, and also to the position of the oral margin, which anteriorly may approach so near to the antennae as to greatly shorten the face. The proboscis is chitinous and shorter than, as long as, or longer than the head-height, while the palpi are comparatively short.

The thorax when viewed from above is more or less rectangular, but in profile varies more or less from normal to decidedly hump-backed; the prothorax is usually distinct from above, but may be more or less hidden by the dorsum, which in some cases is flat or somewhat concave immediately anterior to the scutellar suture, in this respect resembling some species of Dolichopodidae; the notopleural area may merge with the dorsum. The pleurae are usually normal; but in certain cases, where the sternopleurae are produced posteriorly and adjoin the hypopleurae, the pteropleurae are crowded upward between the meta- and sterno-pleurae.

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* Part I, Stratiomyidae, in *Trans. N.Z. Inst.*, vol. 49, p. 172, 1917; Part II, Syrphidae, *l.c.*, vol. 53, p. 289, 1921.

The legs are slender and moderately long, or short and stouter, and are frequently sexually dimorphic—the commonest form being the enlargement of the protarsi; in other forms the mesotarsus (fourth joint) is enlarged, or femora, tibiae, or coxae are unusually developed. The claws and pulvilli are well developed.

In the wings (fig. 1) there is a certain amount of variation of shape and venation. The anal angle may be strongly or moderately developed or altogether wanting; vein Sc either meets the costa or evanesces toward its apex; R_4 and R_5 either branch or are fused throughout. When branching, R_4 leaves R_5 at an acute or right angle, and in some cases is recurved to meet the costa; in one genus (*Blepharoprocta*, not yet recorded in New Zealand) it joins R_{2+3} and not the costa, the recurving being an approach to this state. In some species M_1 and M_2 are wholly or partially fused after leaving cell 1st M_2, and when completely fused may not quite reach the wing-margin. Cu_2 is either recurrent, being more or less parallel with the posterior margin when it is confluent with 1st A, or forms an acute or right angle with 1st A, which at times is more or less completely evanescent, as is sometimes also cell Cu. In many of the Empid wings there is a spurious vein, similar to that of the Syrphidae, running through cells R and R_5; cell 1st M_2 is rectangular, triangular, or narrowed apically, while in some genera (not yet known in New Zealand) it is completely wanting.

The abdomen is more or less robust or slender. The genitalia of the male vary considerably; in some species they are more or less concealed, in others prominent and knob-like. The most unique forms are found in the genus *Hilara*; in many of these flies there is a sheath-like appendage frequently almost as long as the body itself (fig. 2) or much shorter. A dissection of this appendage—which I refer to as the "genital appendage"—shows that it is the sheath of the penis, which is extremely long, the genitalia being attached to it on each side on the upper side at the base. This appendage is blade-like, being laterally compressed, and the penis, which is a flexible, chitinous, thread-like structure, leaves the abdomen ventrally and runs around the edge of the sheath, entering and projecting beyond the genitalia on the dorsal anterior angle of the sheath (fig. 2); the penis is retracted within the genitalia by being drawn upward from the lower edge of the sheath to the upper, as shown by the dotted line. When at rest the genitalia are enclosed (fig. 2A) beneath the dorsal plate of the third-last abdominal segment, the penultimate and ultimate being

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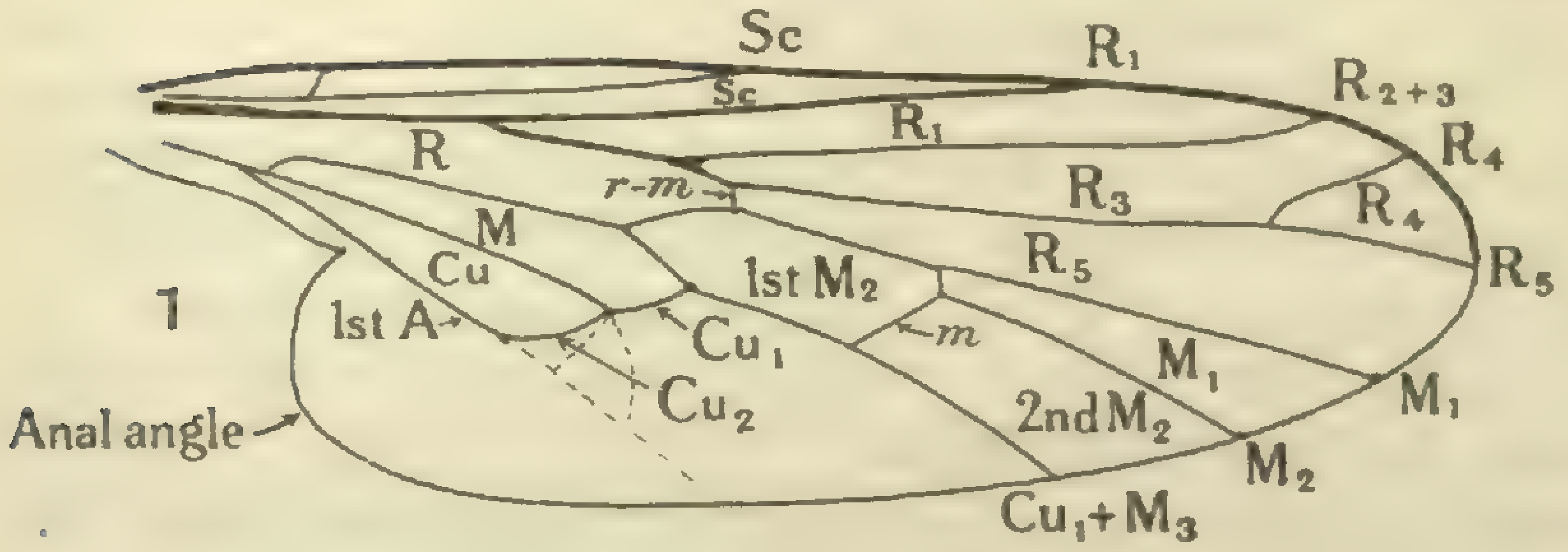
FIG. 1.—Diagram of an Empid wing, showing venation: the dotted lines represent various positions assumed by Cu_2 in relation to 1st A.

FIGS. 2–6.—*Hilara flavinceris* n. sp.

2. Genitalia of ♂, showing the sheath of the penis, or "genital appendage": the dotted line shows position of penis when its apex is withdrawn; the heavy inner line represents the position of the penis. 2A. Genitalia of *H. dracophylli* n. sp., showing the genitalia (black) closed within the abdomen.
3. Apex of abdomen, ♀.
4. Abdomen of ♀, showing bladders inflated.
5. Egg, side view.
6. Egg seen from anterior end, showing micropilar projection.

FIGS. 7–10.—*Hemerodromia fontanalis* n. sp., ♀.

7. Head, side view.
8. Dorsum of thorax, showing chaetotaxy and colour-pattern.
9. Wing.
10. Anterior leg.



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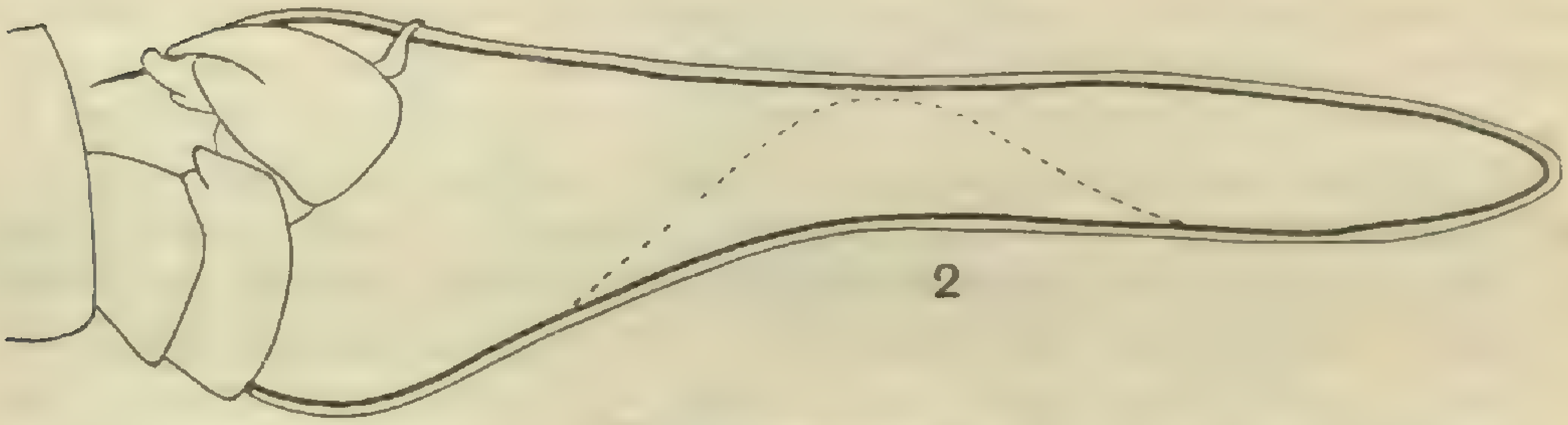
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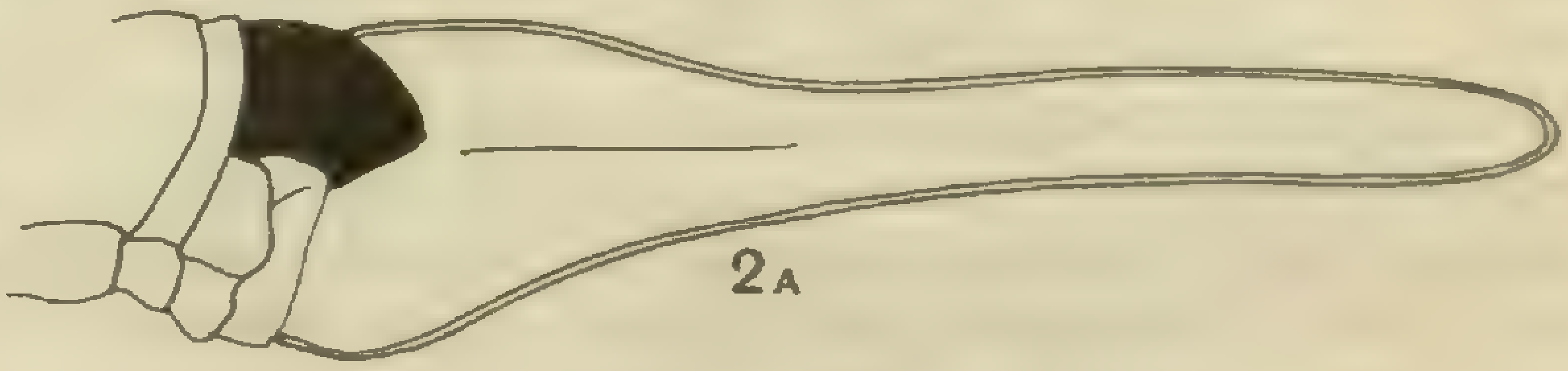
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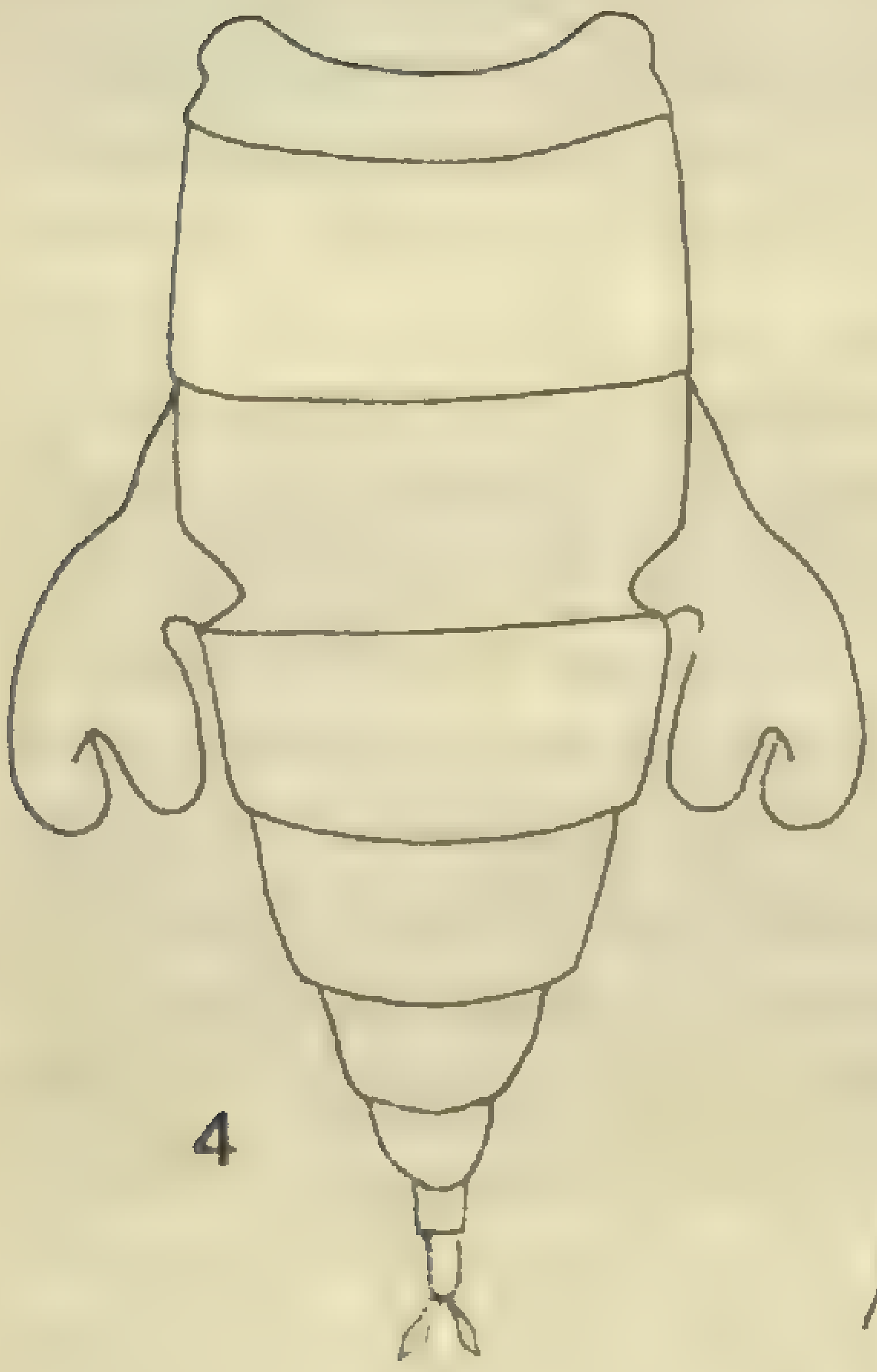
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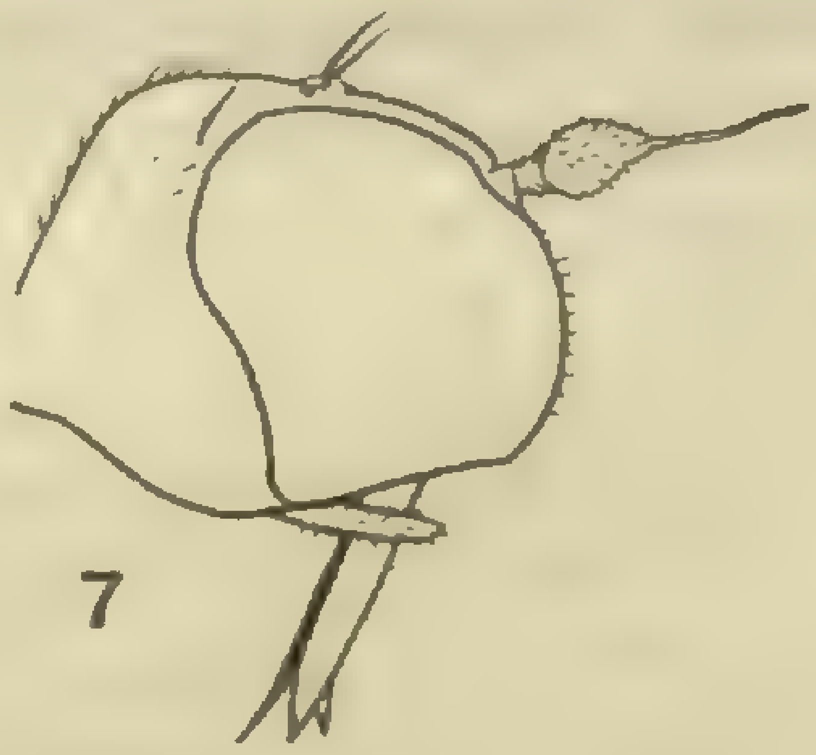
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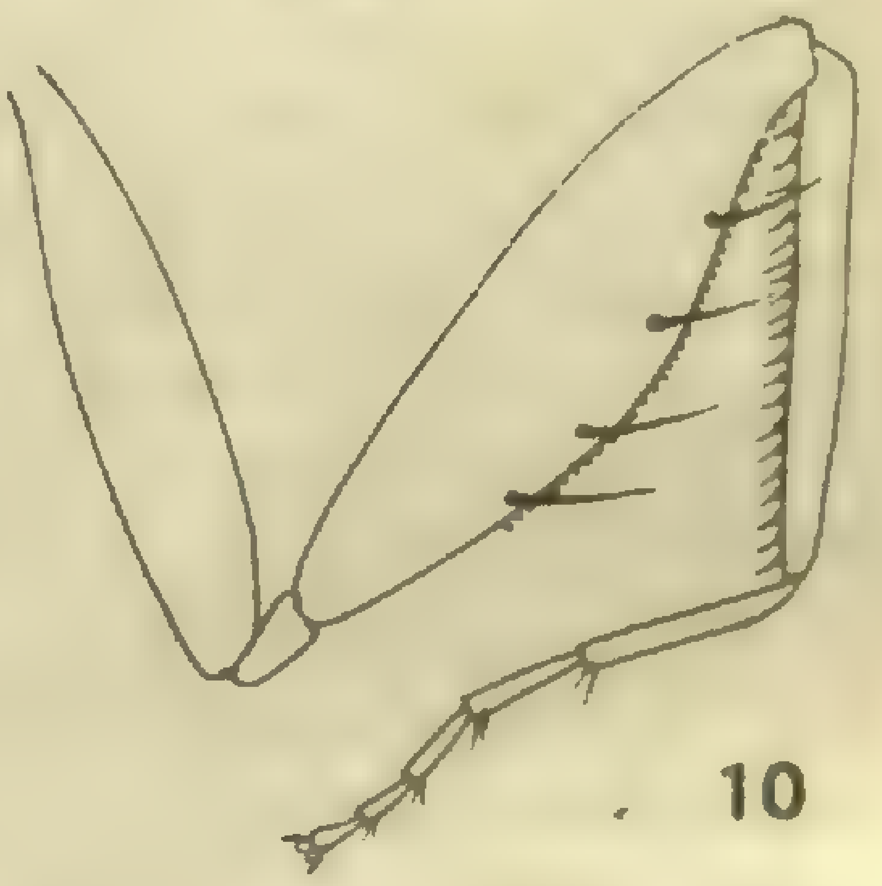
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much shortened in height to receive the genitalia. The female abdomen ends in a pair of stylets, and when the apical segments are extruded they appear as shown in fig. 3. In some species the membrane of the third abdominal segment of the female on each side may be inflated to form a bilobed bladder (fig. 4), the membrane when not inflated forming a whitish wrinkled patch. These peculiar bladders have apparently to do with the aquatic habits of the species, since Mr. J. W. Campbell, who found the specimens, states that the flies (*Hilara flavinceris* n. sp.) were found beneath an overhanging rock above a stream.

The vestiture consists of bristles and hairs, the former arranged in definite systems which are beyond doubt of considerable taxonomic value, and in one or two genera a supplementary synopsis of the species has been drawn up, based on the thoracic and occipital chaetotaxy of the males. It is apparent from the material available that the chaetotaxy of the two sexes in the same species varies to a greater or lesser degree, and when a more complete series of specimens and species is procured a more definite account will be drawn up. The occiput is usually bristly above the foramen and hairy below; ocellar bristles are usually present, and also delicate frontal ones; the first and second antennal joints are bristly or haired, and in some forms there are bristles or hairs on the face; the palpi are bristly or haired. On the dorsum of the thorax the bristles are either well developed or delicate and small, the acrostichals and dorsocentrals frequently being represented by one or more rows of small bristles which usually lengthen posteriorly, the dorsocentrals often ending in a pair of well-developed bristles. The bristles on the prothorax show important variations. The scutellar bristles may be strong or weak, erect or horizontal, and vary greatly in number; they are usually marginal, but discal ones are sometimes present. There are bristles or hairs on the metapleurae of many species. On the wings there may be one or more strong costal bristles near the articulation. The bristles of the legs, when present, are variable; in some species they are large and strong, or short and thorn-like, arising from swellings on the under-side of the femora; the coxae may also be strongly bristled or haired, while on the tibiae are long or short spines; on the lower side of the front protarsi may be a row of minute teeth-like spines. The bristles of the abdomen are usually hair-like, but more conspicuous along the posterior margins of the segments.

The Empididae are predaceous and great hunters; none of them is large, and many are very small; their colours are inconspicuous. They are frequently found skimming over the surface of calm water, or dancing in swarms in the air; other species are solitary. Representatives of the family occur under most conditions, particularly on the foliage of bushes near water, or upon the rocks of streams; certain forms occur on sandy sea-coasts. The life-history of the family is but little known. The larvae of some have been found in the ground and among decaying vegetable matter, and it has been noted that some are carnivorous. It is probable that certain species are semi-aquatic, since a species of *Hemerodromia* has been found in the mud of a stream (Lundbeck).

The writer, while dissecting the abdomen of the female of *Hilara flavinceris* n. sp., found the ovaries filled with yellowish-brown eggs, each of which is oval with one end truncated and surrounded by a narrow rim (fig. 5); this end is covered by a whitish granular membrane from the middle of which is the micropilar projection (fig. 6); the surface of the egg is sculptured by hexagonal depressions.

The following synopsis is adapted to the species herein described only :—

TABLE OF GENERA.

1	Anal angle of wing not or but little developed (figs. 9, 18, 24, 33)	2
	Anal angle more or less developed	5
2	Anterior coxae normal ; two veins from cell 1st M_2 owing to complete fusion of M_1 and M_2 ; R_4 and R_5 fused throughout	Subfam. OCYDROMIINAE, genus *Leptopeza*.*
	Anterior coxae more or less lengthened, at least longer than the posterior ; three veins from 1st M_2, or, when two, then M_1 and M_2, fused for a space before branching ; R_4 and R_5 may branch or be completely fused	3
	Subfam. HEMERODROMIINAE.	
3	Anterior femora and coxae subequal, the anterior femora and tibiae spinose beneath ; R_4 and R_5 fused or branched ; Cu_2 forming an angle with 1st A	4
	Anterior coxae not abnormally lengthened ; legs slender ; R_4 and R_5 branching ; Cu_2 and 1st A confluent forming a loop	*Trichopeza.*
4	R_4 and R_5 fused throughout ; 1st A more or less evanescent ; three veins from cell 1st M_2 ; cell Cu somewhat longer than cell M	*Litanomyia.*
	R_4 and R_5 branching ; M_1 and M_2 fused after leaving cell 1st M_2, but branching before the margin ; 1st A strongly developed ; cell Cu much shorter than cell M	*Hemerodromia.*
5	Cu_2 meeting 1st A at an acute angle, and not more or less parallel to the posterior wing margin ..	Subfam. BRACHYSTOMATINAE, genus *Brachystoma.*
	Cu_2 recurved, being more or less parallel to posterior wing-margin and not forming an acute angle with 1st A	6
	Subfam. EMPIDINAE.	
6	Metapleurae with hairs or bristles	7
	Metapleurae bare	8
7	Face bare	*Empis.*†
	Face more or less haired	*Empimorpha.*†
8	Vein Sc meeting the costa	*Hilara.*
	Vein Sc evanescent distally	*Hilarempis.*†

Subfamily HEMERODROMIINAE.

Anal angle of the wing not projecting, but weakly developed if at all ; R_4 and R_5 may be fused throughout forming one vein (fig. 18), or branch toward the apex in the manner typical of the family (fig. 9) ; cell 1st M_2 may be narrowed apically owing to the elongated *m–cv* being more or less parallel to the posterior margin of the wing ; or triangular, *m–cv* being almost in line with the first section of M_2 ; or rectilinear when the sides are practically parallel, M_1 and M_2 being fused for some distance before separating to the margin (fig. 9). There is also a considerable variation of the cell Cu ; 1st A may be absent or represented by only a faint impression, although Cu_2 is distinct and curves down to meet it (fig. 18).

* *Leptopeza* is an exception to the general characters of the subfamily Ocydromiinae, since other genera of that group have the anal angle developed.

† In *Empis*, *Empimorpha*, and *Hilarempis* Sc is evanescent distally, but the hairs (often very indistinct) or bristles on the metapleurae separate the first two genera from the third.

When well developed, cell Cu may be looped anteriorly, owing to the confluence of 1st A and Cu_2 as one vein (fig. 24), or it may be truncated by Cu_2 being at right angles to 1st A (fig. 9). Further, cell Cu may be equal to, longer, or shorter than cell M.

Genus Hemerodromia Meigen.

The chief characters of this genus are the lengthened anterior coxae—these in length nearly equal their femora, which are thickened and spinose beneath; the elongated thorax; and the presence of two forked veins on the wing, M_1 and M_2 being fused for some distance beyond cell 1st M_2; the vein Sc, also, is evanescent at its apex.

H. fontanalis n. sp.

♀. Head globular, flattened above and below (fig. 7); eyes dichoptic, slightly emarginate at antennae; front cinereous, at times darker, with no bristles or hairs; ocellar triangle cinereous, with a pair of ocellar bristles; ocelli brownish-red. Antennae tawny; third joint fuscous in some lights, clothed with delicate tawny hairs, short, rather ovate but pointed apically, and terminating in a rather robust flagellum somewhat longer than the third joint itself. Face cinereous, clothed with scattered delicate hairs; elongate, very narrow, but broadening beneath at mouth. Proboscis brown, not as long as height of head; palpi pale grey. Occiput swollen, cinereous, with minute indistinct bristles over surface, and pair of distinct orbital bristles toward vertex.

Thorax elongated, black in ground-colour but clothed with cinereous pubescence arranged to form a pair of longitudinal darker narrow strips and an outer darker patch on each side; chaetotaxy as illustrated in fig. 8.

Wings (fig. 9) colourless, veins tawny, main veins thickened; Sc indistinct and evanescent apically; R_{4+5} arising not much in front of origin of R_{2+3}; veins M_1 and M_2 confluent after leaving cell 1st M_2, but branching before reaching costa; 1st M_2 rectangular; cell M much longer than cell Cu, which is somewhat rectangular but pointed basally; Cu_2 at right angles to 1st A. Halteres pale yellow, almost white.

Legs pale tawny, middle and posterior pairs crowded posteriorly, anterior pair well separated from others; sternum of thorax flat. Anterior coxae considerably elongated, almost as long as their femora (fig. 10), which are somewhat swollen, with row of minute black teeth-like spines along lower side, but not extending to base, and a few widely spaced pale-yellow bristles to side; anterior tibiae somewhat thickened, not as long as femora, with row of minute teeth-like spines along lower edge, from each of which arises a small bristle; tarsi normal. Middle and posterior legs slender; all tarsi rather fuscous.

Abdomen black in ground-colour, with cinereous pubescence; terminal stylets shiny black.

♀. Length, 2·5 mm.

Holotype: ♀, No. 1223, D. M.

Habitat.—Rotorua, on banks of a stream.

Genus Litanomyia Melander.

The wing of this genus is characteristic; the anal angle is not developed; 1st A is obsolete, although Cu_2 is distinct and at right angles to the line of 1st A, the cell Cu being longer than cell M; cell 1st M_2 elongate; R_4 and

R_5 are fused throughout their length, and Sc is evanescent apically. Correlated with the absence of 1st A, the anterior coxae are longer than their femora, which are broadened and spinose beneath. The eyes are situated well forward on the head, and the occiput is well developed. In characterizing the genus, Melander states that the head is flattened and the eyes dichoptic in both sexes; acrostichal bristles absent and two scutellar bristles present. In the following species the head is flattened in the male only, and in this sex the eyes are closely approximated beneath the antennae; a pair of acrostichal bristles is present on the anterior part of the dorsum, and in the female, besides the two apical scutellar bristles, there are four on each angle of the scutellum. The occipital chaetotaxy varies in the male and female.

L. otiraensis n. sp.

♂. Head (fig. 11) dorso-ventrally flattened; eyes angulated at ocellar triangle and emarginate at antennae, dichoptic above antennae but closely approximated below, restricting the face and reaching to oral margin eliminating the cheeks. Ocellar triangle placed well forward on head; a pair of stout and conspicuous ocellar bristles. Front cinereous, comparatively broad, with a distinct orbital bristle on each side toward antennae; otherwise bare. Antennae situated in depression a little above middle height of head; black in ground-colour, but with greyish reflection; first joint short and inconspicuous but strongly bristled; second joint more or less globular and bristly; third joint rather clavate, flat, clothed with short delicate hairs; style a little more than three times as long as third joint, yellowish-brown, thickened at base, and clothed with delicate bristle-like hairs, giving it a barbed appearance except at tip, which is bare and hair-like.

Face narrow, convex, projecting in profile (fig. 11), clothed with dense silvery pubescence. Proboscis tawny, awl-like, slightly curved, not as long as height of head; palpi large, tawny, ultimate joint ovate, penultimate clavate. Occiput cinereous, flat and bristly above and clothed below with silvery bristle-like hairs along orbits; lower angle bristly; posterior orbits convex above but angulate about middle and thence concave to oral margin. Occipital chaetotaxy shown in fig. 13.

Thorax very elongate, dorsum narrow, chaetotaxy prominent and shown in fig. 15, except posterior to suture and in front of scutellum, where the specimen is pinned. Dorsum cinereous grey, owing to pubescence, with black stripe on each side and an indistinct brownish medium one; scutellum cinereous, bristles erect and convergent. Pleurae blackish-brown but clothed with cinereous pubescence; middle and posterior coxae approximated and set well back under base of abdomen, anterior legs attached anteriorly; metapleurae with pair of distinct bristles.

Wings (fig. 18) clear, anal angle weak, 1st A absent, Cu_2 distinct, forming right angle with line of 1st A; R_4 and R_5 fused; Sc evanescent for most part. Halteres tawny. Legs tawny, knees and apices of tarsi somewhat fuscous; anterior coxae (fig. 19) as long as their femora, which are broadened, and have two rows of long and short teeth-like spines beneath, between which tibiae fold; row of closely set, minute black spines along inner side of anterior tibiae; anterior tarsal joints, except the protarsi, slightly broadened.

Abdomen tawny, posterior margin of each segment broadly banded with fuscous; sparse vestiture of delicate tawny hairs; distinct bristles

toward posterior margin of each segment. Genitalia extruded but indistinct, tawny and bristly.

♀. Eyes dichoptic, front perpendicular, narrowing to antennae, black, orbits greyish-yellow, short owing to occiput invading crown of head so that ocellar triangle is on front of head (fig. 12). Face narrow, longer than front, protruding as in male, and clothed with dense yellow pubescence. Antennae inserted a little below middle line of head. Oral margin produced backwards and bristly. Occiput more or less evenly rounded; chaetotaxy shown in fig. 14; short bristle-like hairs below foramen and in deep concavity of posterior orbits. Lower orbits truncated.

Thorax somewhat rectangular in outline, particularly in profile (fig. 17); prothorax yellowish-brown, to black in some lights; dorsum (fig. 16) greyish-yellow or brown, with velvet blackish-brown stripe on each side; medianally is a broad deeper-yellow stripe, bordered on each side by a narrow, less distinct, slate-grey one; median colour-pattern distinct only anterior to transverse suture. Outside lateral blackish-brown stripes thorax is yellowish-grey edged with blackish-brown. Humeri, from above, truncated and yellowish-grey. Scutellum greyish-yellow, with four marginal bristles at each angle in addition to apical pair. Metathorax brownish-yellow, but black in some lights. Pleurae silvery-grey in colour, with blackish-brown areas in certain light (fig. 17). Owing to sternopleurae being produced posteriorly and being closely applied to hypopleurae, not only are pteropleurae crowded upwards between meta- and sterno-pleurae, but middle and posterior legs arise close together immediately posterior to root of wings (which are attached well back on thorax) and beneath base of halteres, a space equal to about length of dorsum intervening between anterior and middle legs, which are attached to extreme anterior lower angle of thorax. Chaetotaxy conspicuous, and shown in figs. 16 and 17; pleurae bare except for five metapleural bristles.

Legs yellow, coxae with whitish reflections; knees, tibiae of middle and posterior legs, and all tarsi somewhat darker; anterior coxae a little longer than their femora.

Abdomen brownish-yellow, with bristle-like hairs on posterior margin of each segment; pale-yellowish hairs along sides; brown terminal stylets covered with stiff bristle-like hairs.

♂. Length, 2 mm. ♀. Length, 3 mm.

Holotype: ♂, No. 1253; ♀, No. 1225, D. M.

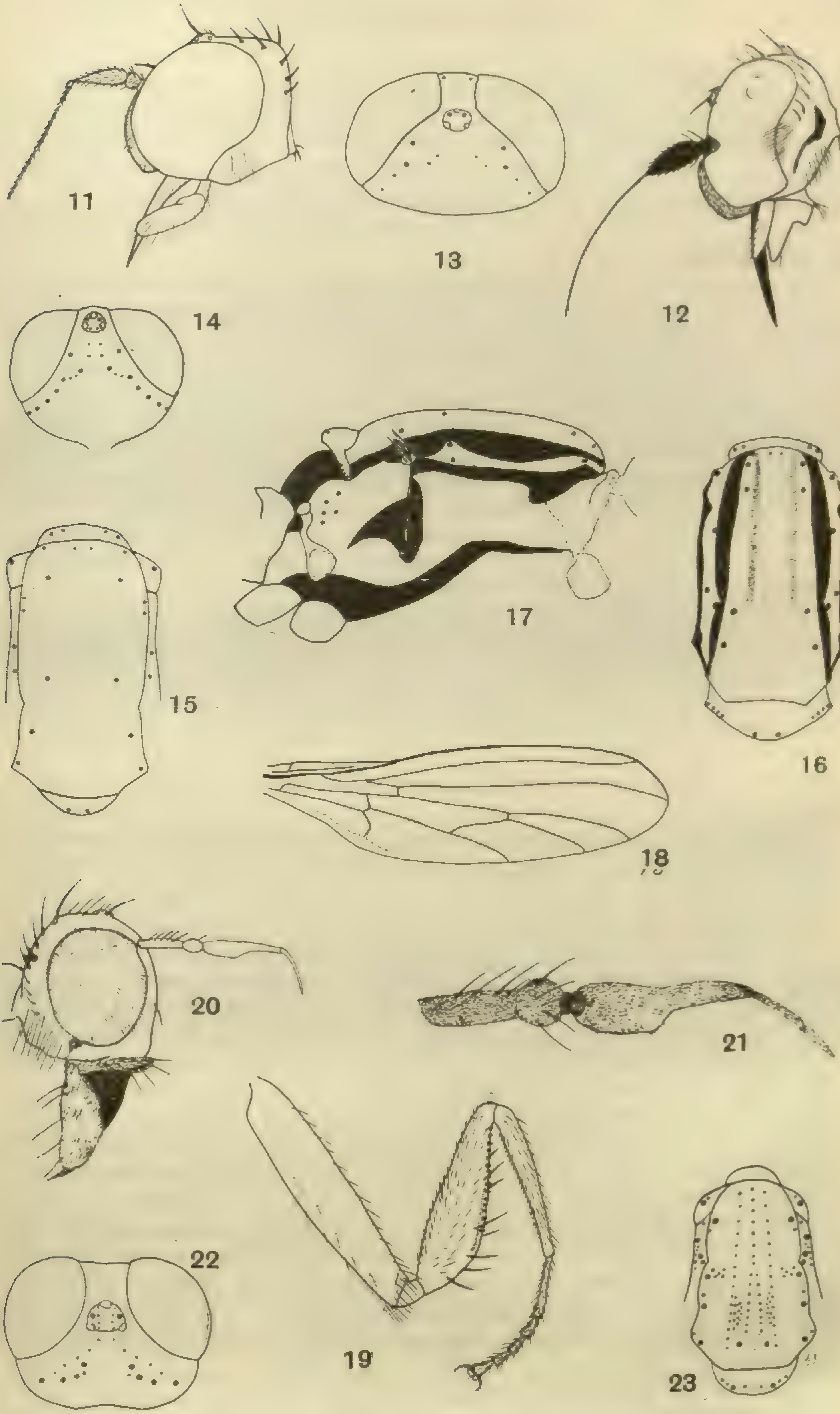
Habitat.—Otira (J. W. Campbell); Weraroa, amongst swamp vegetation.

FIGS. 11–19.—*Litanomyia otiraensis* n. sp.

11. Head, side view, ♂.
12. Head, side view, ♀.
13. Occiput, showing chaetotaxy, ♂.
14. Occiput, showing chaetotaxy, ♀.
15. Dorsum of thorax, showing chaetotaxy, ♂.
16. Dorsum of thorax, showing colour-pattern and chaetotaxy, ♀.
17. Thorax, showing colour-pattern and chaetotaxy of pleurae and part dorsum, ♀.
18. Wing.
19. Anterior leg.

FIGS. 20–23.—*Trichopeza longipennae* n. sp.

20. Head, side view.
21. Antenna.
22. Occiput, showing chaetotaxy.
23. Dorsum of thorax, showing chaetotaxy.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Genus TRICHOPEZA Rond.

The following species, which I have placed in *Trichopeza* for the time being, does not altogether agree with the characters given for the genus. The chief points of difference are: Third joint of antennae elongate and clavate with a somewhat shorter articulated style; eyes not touching below antennae; acrostichal bristles uniserial anterior to the transverse suture but biserial posterior to this; the tibiae have a stout apical spine.

T. longipennae n. sp.

Head cinereous; eyes minutely hairy, slightly emarginate at antennae, approximated slightly on middle of front, which is short, without vestiture but with an indistinct brownish transverse median band. Ocellar triangle situated a little forward of middle of top of head, owing to encroaching occiput (fig. 20); a pair of conspicuous ocellar bristles, between which run two rows of small bristles to posterior margin of triangle (fig. 22). Antennae longer than width of head, above middle line of which they are inserted and closely approximated (fig. 20); cinereous and minutely pubescent; first joint long, with bristles above; second joint short and globular, bristly above and below; third joint considerably longer than first and second together, clavate, being abruptly constricted in lower margin toward apex; flagellum three-fifths as long as third joint (fig. 21).

Face cinereous, with pair of delicate bristles in middle (fig. 20); cheeks narrow, cinereous, eyes descending close to oral margin; a deep furrow at lower eye-margin toward posterior oral angle, which bears long stiff greyish hairs extending on to lower occiput. Palpi greyish-black, densely clothed with greyish pubescence and with long rigid greyish hairs. Proboscis not quite length of head-height, stout, and ending in an acute recurved point. Occiput cinereous, convex, bristly above, hairy below, chaetotaxy arranged as in fig. 22.

Dorsum of thorax somewhat humped, but flattened before scutellum; black-margined, with cinereous and with medium grey stripe which broadens over the flattened area posteriorly; on each side of stripe is a narrow indistinct pale one, seen only in certain lights; alar regions reddish-brown in some lights, with a greyish stripe running to scutellar suture. Chaetotaxy distinct and arranged as in fig. 23; pleurae cinereous and bare.

Wings (fig. 24) much longer than body and projecting far beyond abdomen, slightly tinged with brown; costa distinctly developed around posterior margin; numerous long and strong costal bristles at articulation; anal angle not strongly developed; vein Sc evanescent before reaching costa; R_4 angulated and with a short stump in wing of male (fig. 24A); in female R_4 is strongly rounded after leaving R_5; Cu_2 and 1st A confluent, forming a loop. Halteres elongate, stalks tawny, large heads brownish.

Legs bristly, long and slender, cinereous, but tarsi merging to black; anterior coxae longer than posterior, on anterior surface clothed with yellowish bristle-like hairs and numerous stout black spines (fig. 25). Femora, tibiae, and tarsi with numerous long hair-like bristles; tibiae with stout apical spine; anterior protarsi (fig. 26) with row of widely separated short and stout spines beneath; anterior metatarsi flattened and broadened anteriorly.

Abdomen cinereous-black, sparsely clothed with long hair-like bristles, denser along posterior margin of each segment, on each side of which is a black circular depression. Male genitalia black, projecting, structure obscure (fig. 27); apex of female abdomen ending in pair of broad lamellae (fig. 28).

♂. Length, 4·5 mm. ♀. Length, 5 mm.
Paratypes: No. 1251, D. M.
Habitat.—Otira (J. W. Campbell).

Subfamily OCYDROMIINAE.

Veins R_4 and R_5 fused throughout; M_1 and M_2 either distinct or fused throughout—*i.e.*, there may be two or three veins running from cell 1st M_2. In some genera Cu_2 is recurrent or forms a right angle with 1st A. The anal angle is weak or strongly developed.

Genus LEPTOPEZA Macq.

Cell 1st M_2 present; veins M_1 and M_2 fused throughout; Cu_2 not forming an acute angle with 1st A, the cell Cu being shorter than cell M; anal angle rounded, not strongly developed. Antennae short, three-jointed, the third joint broad at the base but pointed apically and terminated by a long bristle-like style.

TABLE OF SPECIES.

(*a.*) A black fly with tawny legs .. .. *nigra* n. sp.
(*b.*) An orange-yellow fly with abdominal segment branded with fuscus .. .. *fulvescens* n. sp

Provisional Table based on Chaetotaxy.

(*a.*) One pair of scutellars; four weak prothoracics on each side (fig. 35); occipitals in two rows, the outer stronger, the inner weaker, and ending in a pair of weak verticals on each side of ocellar triangle (fig. 34) .. .. *fulvescens* n. sp.
(*b.*) Two pairs of scutellars; two weak prothoracics on each side (fig. 32); occipitals in two rows, the outer weaker, the inner stronger, and not reaching vertex; a weak bristle close to orbit opposite the terminal one of the inner row (fig. 31) .. *nigra* n. sp.

L. nigra n. sp.

♂. Perpendicular axis of head long; eyes situated well forward, emarginate at antennae, below which they are holoptic, face being almost completely eliminated (fig. 29); above antennae eyes are closely approximated, the black front in consequence being very narrow; ocellar triangle broad, reaching from eye to eye, black, ocelli golden; a pair of conspicuous ocellar bristles. Antennae situated high up on head, black; first and second joints short and of about equal length (fig. 30), both clothed with minute hairs, second globular and with fringe of bristles; third joint longer than first and second together, flat, broad basally but pointed apically, and clothed with short and delicate grey hairs; arista very long, bristle-like, and minutely setose. Face black, extremely narrowed owing to eyes being holoptic for some distance below antennae and thence closely approximated; cheeks eliminated by eyes; only apex of mouth-parts projecting; proboscis brownish and palpi black. Occiput large, convex, cinereous-black; clothed with greyish hairs below, bristly above; chaetotaxy shown in fig. 31.

Thorax humped, cinereous-black, but practically black in some lights; pleurae bare, lighter in colour than dorsum, which is clothed with short delicate bristles and larger ones arranged as in fig. 32. (The course of acrostichals toward scutellar suture is lost owing to position of pin through the only specimen.) Four bristles on scutellum, the two outer ones shorter and more delicate than the apical pair, which are long and convergent.

Wings (fig. 33) iridescent, slightly tinged with yellow, anal angle not strongly developed; 1st A continued toward margin; Cu_2 inclined to evanesce at its junction with 1st A; vein Sc evanescent before reaching costa; veins R_4 and R_5 fused throughout; M_1 and M_2 fused; a spurious vein in cell Cu; surface and costa of wing distinctly bristly. Halteres tawny.

Legs tawny and bristly; upper surface of femora and apical joints of tarsi darker; front femora with row of strong bristles on inner side; posterior femora with delicate bristles on lower side and strong pre-apical lateral one; middle tibiae with strong pre-apical bristles and strong lateral one near middle and another on upper side above middle; posterior tibiae with apical bristles and strong one on upper side slightly beyond middle; posterior protarsi rather thickened.

Abdomen blackish-brown, sparsely clothed with short delicate bristles, and a system of long hair-like ones along the posterior margin of each segment.

♂. Length, 3·5 mm.

Holotype: No. 1252, D. M.

Habitat.—Silverstream, Dunedin (E. Clarke).

L. fulvescens n. sp.

♀. Eyes closely approximated along front, deeply emarginate at antennae; ocellar triangle prominent, black with a greyish reflection and a pair of conspicuous ocellar bristles; front narrow but widening slightly to antennae, black, but brownish in some lights, and with greyish pubescence longer at antennae, which are inserted a little above middle height of head; first and second joints of about equal length, black but clothed with greyish pubescence and fringe of bristles; third joint elongate, clavate, clothed with greyish pubescence and terminated by pubescent style not abnormally long nor unusually slender. Face narrow, black, and clothed with a short silvery pile which becomes yellow at oral margin. Proboscis brown, short, and stout; palpi tawny, apical joint broad and ovate. Occiput black, clothed with cinereous pubescence, the hairs below tawny, chaetotaxy above arranged as in fig. 34.

Thorax orange-yellow, vitreous, narrow black streak running from humerus to wing; metanotum blackish-brown. Very few bristles on

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FIGS. 24–28.—*Trichopeza longipennae* n. sp.

24. Wing of ♀.
24A. Wing of ♂, showing stump-vein on R_4.
25. Anterior coxa, ♂.
26. Anterior tarsus, ♂.
27. Genitalia, ♂.
28. Apex of abdomen, ♀.

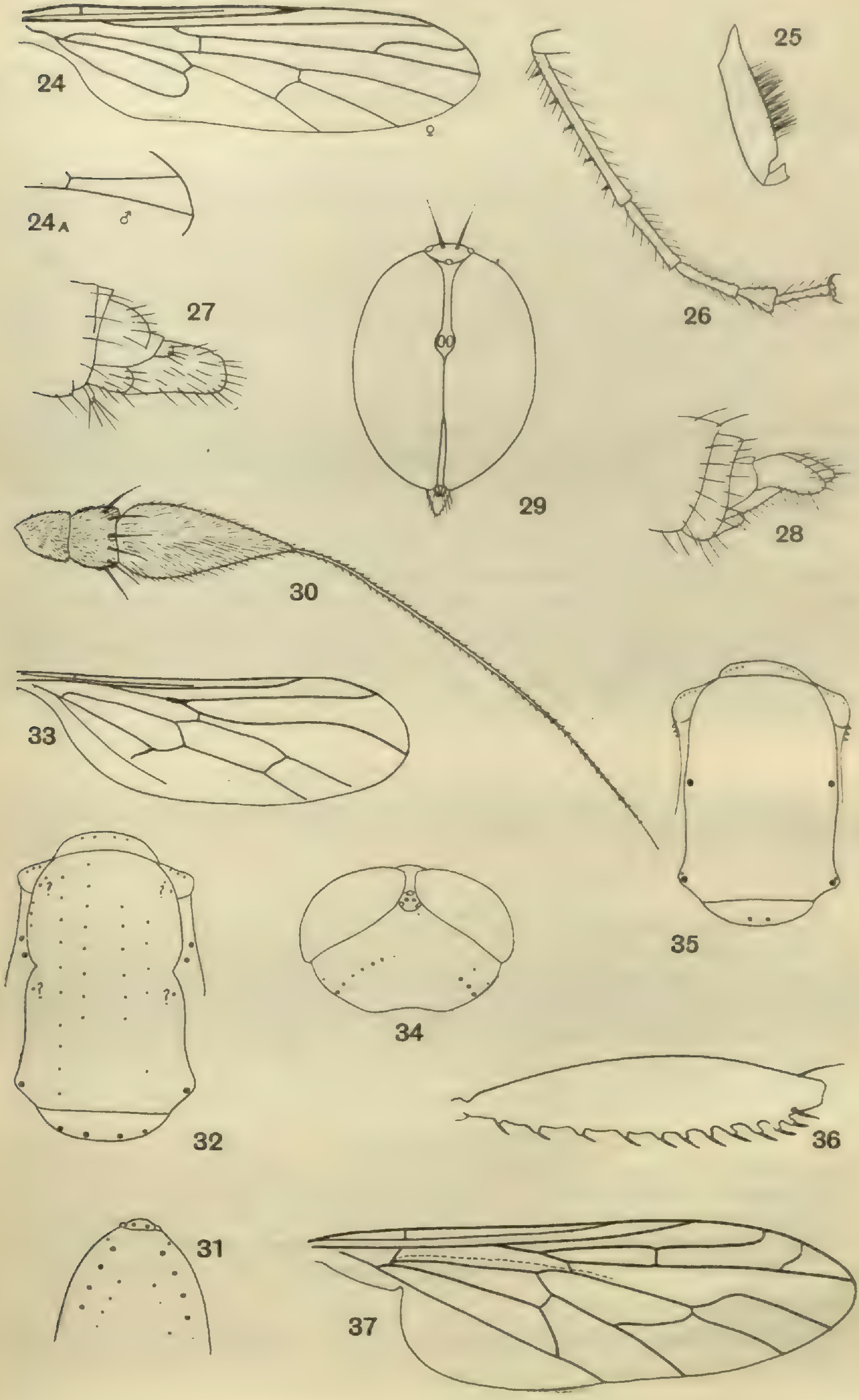
FIGS. 29–33.—*Leptopeza nigra* n. sp.

29. Head, front view, ♂.
30. Antenna.
31. Occiput, ♀, showing chaetotaxy.
32. Dorsum of thorax, showing chaetotaxy.
33. Wing.

FIGS. 34–36.—*Leptopeza flavescens* n. sp.

34. Occiput, ♀, showing chaetotaxy.
35. Dorsum of thorax, showing chaetotaxy.
36. Posterior femur, ♀.

FIG. 37.—*Brachystoma adelensis*: Wing.



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♀
24A
♂
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dorsum, but several systems of delicate hairs, some representing the acrostichals; but the dorsum is too much damaged by the pin to give a definite account. Chaetotaxy, as far as possible, shown in fig. 35. A unique feature is that on the edge of the notopleurae, just posterior to the humeri, are very minute black teeth-like spines. There is a single pair of erect apical bristles on the scutellum.

Wings with the anal angle more pronounced than in *L. nigra;* vein 1st A, though weak, is continued well to the margin; venation otherwise as in *L. nigra.* Halteres brownish on the stalks but with greenish-yellow heads.

Legs tawny; apices of femora, tibiae and proximal tarsal joints, apical tarsal joints, and a spot distally on posterior femora fuscous. Anterior and middle femora slightly thickened, posterior strongly so; middle femora with row of bristles beneath but not extending to apex, and with three lateral pre-apical bristles, two on one side and one on the other; posterior femora with row of stout spines beneath (fig. 36), to one side, each spine arising from a prominence along which tibiae close, and with pre-apical bristles and bristle-like hairs above. Anterior tibiae clothed with delicate hair-like bristles; middle tibiae with delicate bristles and apical ones; posterior tibiae more delicately bristled and with a stronger pre-apical one.

Abdomen orange-yellow, posterior margin of each segment broadly banded with brownish; apical segment terminated by a long narrow process which has black rounded apex giving rise to pair of long delicately-bristled styles.

♀. Length, 4·5 mm.

Holotype: No. 1254, D. M.

Habitat.—Otira (J. W. Campbell).

Subfamily BRACHYSTOMATINAE.

Cu_2 forms an acute angle with 1st A; the anal angle is well developed; R_4 and R_5 are not fused throughout.

Genus Brachystoma Meigen.

In his characters of this genus Melander* states that the anal angle of the wing is gone, while Shiner† asserts that this angle projects (*Flugellappen vortretend*). It is upon the latter author's classification that I place the following species in *Brachystoma*, although the eyes of both species are not holoptic, but widely separated beneath and holoptic above the antennae in both sexes. The two following species agree so closely that it is with some hesitation I separate them; the genitalia of the males, however, differ to some extent.

Table of Species.

A supernumerary cross-vein connecting veins R_{2+3} and R_{4+5}; claspers of ♂ genitalia with a row of strong spines along the inner edge	*adelensis.*
No supernumerary cross-vein; claspers of ♂ genitalia without strong spines along inner edge, but terminated by stout spines ..	*hamiltoni* n. sp.

B. adelensis Miller (fig. 37).

B. adelensis Miller, *Trans. N.Z. Inst.*, vol. 45, p. 203, figs. 11 to 14, and pl. 1, fig. 2, 1913. (N.B. The dimension-lines are reproduced twice natural size.)

Holotype: ♂, No. 786, D. M.

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* Mono. N. Amer. Empididae, *Trans. Amer. Ento. Soc.*, vol. 28, p. 259, 1902.

† *Fauna Austriaca, Die Fliegen*, 1 Th., p. 117, 1862.

B. hamiltoni n. sp.

Eyes holoptic on front in both sexes, covering sides and top of head. Antennae inserted about middle line of head, prominent, densely pubescent, blackish-brown, a golden pubescence particularly noticeable on style, which is two-jointed, basal joint short, terminal joint ending in short naked spine-like process, the two joints together being about as long as clavate third antennal joint (fig. 38). Face bare, short, shorter than broad, greyish-white but blackish along orbits. Cheeks bare, cuneiform, concave, blackish with greyish reflection. Occiput flat, somewhat depressed above foramen but rather swollen beneath and slightly descending at posterior oral margin; black in ground-colour but with distinct greyish-yellow tomentum, sparsely clothed with delicate yellowish-brown hairs below and row of delicate short black orbital bristles above foramen. Ocellar triangle prominent, blackish-brown, ocelli golden; pair of prominent ocellar bristles. Proboscis and palpi withdrawn, blackish-brown with somewhat lighter reflections; apex of proboscis shiny black; palpi bristly.

Thorax distinctly humped in profile; prothorax and humeri greyish-yellow, the former dusky on each side in certain lights; dorsum velvet-brown, a greyish-yellow stripe on each side, with reddish tinge, extending from humeri to alar angles, outside of which is a velvet-brown narrow stripe from humeri to wing-bases; alar angles greyish-yellow; a broad light-brown medio-longitudinal stripe (indistinct in some lights except at scutellum) extending from near prothorax and broadening toward scutellum, which is greyish-yellow; in certain lights the darker colours of dorsum merge in front of scutellum into the lighter; metathorax greyish-brown. Dorsum bare except for a few small bristles (fig. 39), the series toward root of wing, however, being large and conspicuous; a fringe of delicate, rather reclinate bristles along anterior margin of prothorax; scutellum with fringe of delicate bristle-like hairs.

Wings (fig. 40) clouded with brown, more so apically, a clear space on each side of stigma which is opaque-brown; veins brown; anal angle prominent; R_4 not strongly recurved; no supernumerary cross-vein between R_{2+3} and R_{4+5}; apex of cell Cu somewhat obtuse in comparison with that of *B. adelensis*. Halteres light-yellow.

Legs black with silvery rather yellowish-grey reflection, which is particularly persistent on coxae. Middle legs shorter than others and with swollen femora; anterior and posterior legs slender but apex of tibiae and protarsi slightly thickened. Leg chaetotaxy as in *B. adelensis*.

Abdomen blackish-brown with delicate pale hairs at sides; basal and second segments greyish-brown, and a greyish-brown triangular area toward posterior angles of each segment, upon which is a paler brown and indistinct band; this pattern seen only in certain lights. Male genitalia (fig. 41) black, claspers bristly and each terminating in stout bristles; their inner edges not spined; median ventral process bare and shiny; whole genitalia directed upwards. A pair of spots on sides of each abdominal segment except first; on second segment a double row on each side along posterior margin.

♂. Length, 8 mm. ♀. Length, 8·5 mm.

Syntypes: No. 1226, D. M.

Habitat.—Te Wairoa. A very common species in vicinity of waterfall.

Subfamily EMPIDINAE.

Anal angle of wing developed; Cu_2 forming an obtuse angle or confluent with 1st A; cell 1st M_2 present; vein Sc complete or evanescent apically; R_4 and R_5 fused throughout or branching.

Genus Hilara Meigen.

Anterior protarsi of male usually enlarged; proboscis not longer than but about as long as head-height; vein Sc meeting costa; R_4 and R_5 branching; metapleurae bare.

Table of Species.

1	Thorax tawny, with indistinct darker stripes; abdomen brownish-yellow, the posterior margin of each segment tawny; genital appendage of ♂ nearly as long as body; length of body, 6 mm.	♂ *flavinceris* n. sp.
	Thorax not tawny; greyish or blackish species	2
2	Altogether cinereous or greyish species with yellow legs ..	3
	Blackish species	5
3	Altogether a cinereous littoral species; length, 2·25 mm. ..	*philpotti.*
	Body greyish, legs yellow	4
4	Wings tinged with yellow	♀ *smithii.*
	Wings clear; a long genital appendage	♂ *vector* n. sp.
5	Wings tinged with brown	6
	Wings hyaline	7
6	A narrow-bodied fly; ♂ without genital appendage; length, 6 mm.	*fumosa.*
	A small fly; ♂ with a short genital appendage; length, 4 mm.	*fossalis* n. sp.
7	Genitalia of ♂ distinct, recurved over apex of abdomen, but without genital appendage; length, 3·75 mm.	♂ *littoralis* n. sp.
	Genitalia of ♂ with a distinct appendage; length not less than 5 mm.	8
8	Genital appendage short; length of body, 5·5 mm.	*hudsoni.*
	Genital appendage nearly as long as body; length of body, 6 mm.	♂ *dracophylli* n. sp.

*Provisional Table based on Chaetotaxy.**

1	Two pairs of scutellars	2
	At least three pairs of scutellars	3
2	Acrostichals biserial and strong; dorsocentrals uniserial and strong (fig. 52); occipitals in two rows, the two vertical ones of inner row outstanding (fig. 51)	*fumosa.*†
	Acrostichals absent; dorsocentrals biserial (?), the inner row regular and weak, the outer irregular in size (fig. 55); occipitals weak, in two rows, three on each side of vertex strong (fig. 54)	*fossalis* n. sp.
3	Three pairs of scutellars; acrostichals weak, forming at least four rows; dorsocentrals uniserial, terminal ones outstanding, remainder weak (fig. 57)	*smithii.*
	More than three pairs of scutellars	4
4	Five pairs of scutellars; acrostichals weak, in at least four rows; dorsocentrals weak, biserial (fig. 49); occipitals in three rows, the outer triserial, weak but for two strong orbitals (one of which is a vertical) and one strong post-vertical on each side (fig. 48)	*vector* n. sp.
	Four pairs of scutellars and sometimes a pair of discals ..	5
5	Acrostichals absent; dorsocentrals uniserial, weak but ending posteriorly in a strong bristle; the outer and pre-apical scutellars outstanding (fig. 46); occipitals weak, in four rows	*littoralis* n. sp.
	Acrostichals present	6
6	Apical scutellars weak, sometimes a pair of discals present ..	7
	Scutellars uniform, no discals present (fig. 43)	*flavinceris* n. sp.
7	A pair of scutellar discals sometimes present; marginal scutellars, except weak apical pair, uniform; dorsocentrals ending posteriorly in a pair of large bristles before scutellum (fig. 50)	*dracophylli* n. sp.
	Apical scutellars weak, the pre-apicals outstanding; no discals present; dorsocentrals ending in two pairs of outstanding bristles posteriorly	*hudsoni.*

* *H. philpotti* is not included.

† It is doubtful if *H. fumosa* belongs to this genus.

H. philpotti Miller.

H. philpotti Miller, *Trans. N.Z. Inst.*, vol. 45, p. 202, figs. 9 and 10, 1913.

In fig. 10 the vein Sc should not be evanescent, but should meet the costa, though indistinctly. The cone-shaped protuberance referred to in the original description is really the very short genital appendage.

H. flavinceris n. sp.

♂. Eyes emarginate at antennae, narrowly approximated for a distance on front below ocellar triangle, which is prominent and tawny, but greyish-brown pruinose to black in some lights; ocelli orange; a pair of short ocellar bristles and several minute ones behind (fig. 42). Front very narrow at approximation of eyes but broadening below to antennae, gently descending along eye approximation but almost vertically from thence to antennae, thus angulate in profile; tawny and greyish-brown pruinose; a double row of delicate and short hair-like orbital bristles, not extending to line of antennae, which are inserted about the middle line of head; first and second joints tawny and greyish-pruinose, with delicate bristles, first somewhat longer than second; third joint of both antennae lost. Face bare, coloured as front, slightly longer than broad, oral margin not extending very close to antennae. Cheeks very much restricted and inconspicuous, clothed with tawny hairs. Proboscis orange-yellow to brown, equal to or a little less than height of head; palpi tawny, clothed with delicate tawny hairs basally and with a few long bristle-like tawny hairs below apically. Occiput convex, greyish-yellow, with darker reflections due to minute pubescence; a broad area along each orbit clothed with short black bristles merging into long golden stiff hairs below; in bristly area toward vertex is a regular system of chaetae (fig. 42).

Thorax tawny, greyish-yellow pruinose, pleurae black in some lights; dorsum somewhat arched, testaceous in some lights, with four darker longitudinal stripes seen when light falls from in front; chaetotaxy as in fig. 43, there being very few strong bristles; pleurae bare except propleurae, which are clothed with delicate yellow hairs extending on to humeral areas. Scutellum with triangular testaceous area at base, otherwise tawny, with four pairs of erect marginal bristles.

Wings faintly tinged with tawny; veins tawny; vein Sc not evanescent but meeting costa; R_4 strongly curved forward after leaving R_5. Halteres tawny.

Legs tawny, darker at apex of tarsi, not strongly bristled but bristles more distinct at apices of joints; anterior protarsi somewhat thickened; pulvilli tawny; claws black on distal half but tawny on basal half, owing to tawny pubescence.

Abdomen rich brownish-yellow, but tawny across posterior margin of each segment and at sides; clothed with long delicate tawny hairs, which become bristle-like on apical segment and laterally on posterior margin of each segment. Along sides of abdomen are clear pit-like spots. Genital appendage almost as long as body, tawny in colour but fuscous along lower edge.

♂. Length, 6 mm.; + genital appendage, 11 mm.

Holotype: 1208, D. M.

Habitat.—George's Stream, Wainuiomata (G. V. Hudson).

H. littoralis n. sp.

♂. Eyes dichoptic, emarginate at antennae; front brownish-black, with cinereous reflections and a row of delicate bristles on each side; ocellar triangle brownish-black, with pair of strong ocellar bristles. Face short and cinereous. Antennae (fig. 44) large, black with silvery reflection, third joint clavate with short style. Proboscis a little longer than head-height, directed downwards, blackish-brown; palpi short and black, but brownish basally. Occiput cinereous and bristly (fig. 45).

Thorax blackish-brown in ground-colour, pleurae cinereous to silvery; pteropleurae with transverse row of delicate grey bristles; dorsum (when viewed with light falling from in front) narrowly margined on each side with blackish-brown; adjoining this margin is a silvery area and centrally a large reddish-brown area with a pair of indistinct darker stripes more conspicuous anteriorly behind head, where the reddish-brown merges into a cinereous reflection (fig. 46); the whole surface distinctly bristly, among which is a system of chaetae as in fig. 46. Metanotum cinereous.

Wings not coloured, veins tawny; Sc ending in costa; anal angle prominent. Halteres brown.

Legs brown, tarsi black; bristly; anterior protarsi somewhat enlarged.

Abdomen bristly; black with cinereous reflections. Genitalia more or less almond-shaped when viewed from above; in profile (fig. 47) lying forward over dorsal surface of apical abdominal segments.

♂. Length, 3·75 mm.

Holotype: No. 1165, D. M.

Habitat.—Occurring in large numbers on sandy sea-beach at the mouth of the sluggish Hokio Stream.

H. vector n. sp.

♂. Eyes as in *H. flavinceris;* ocellar triangle black with brownish-grey tomentum; the pair of ocellar bristles easily distinguished from the smaller posterior series; ocelli amber-yellow; front black with grey tomentum and row of delicate bristles along orbits. First and second

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FIGS. 38–41.—*Brachystoma hamiltoni* n. sp.

38. Antenna.
39. Dorsum of thorax, showing chaetotaxy.
40. Wing.
41. Genitalia, ♂.

FIGS. 42, 43.—*Hilara flavinceris* n. sp.

42. Occiput, ♂, showing chaetotaxy.
43. Dorsum of thorax, showing chaetotaxy.

FIGS. 44–47.—*Hilara littoralis* n. sp.

44. Antenna.
45. Occiput, ♂, showing chaetotaxy.
46. Dorsum of thorax, showing colour-pattern and chaetotaxy.
47. Genitalia, ♂.

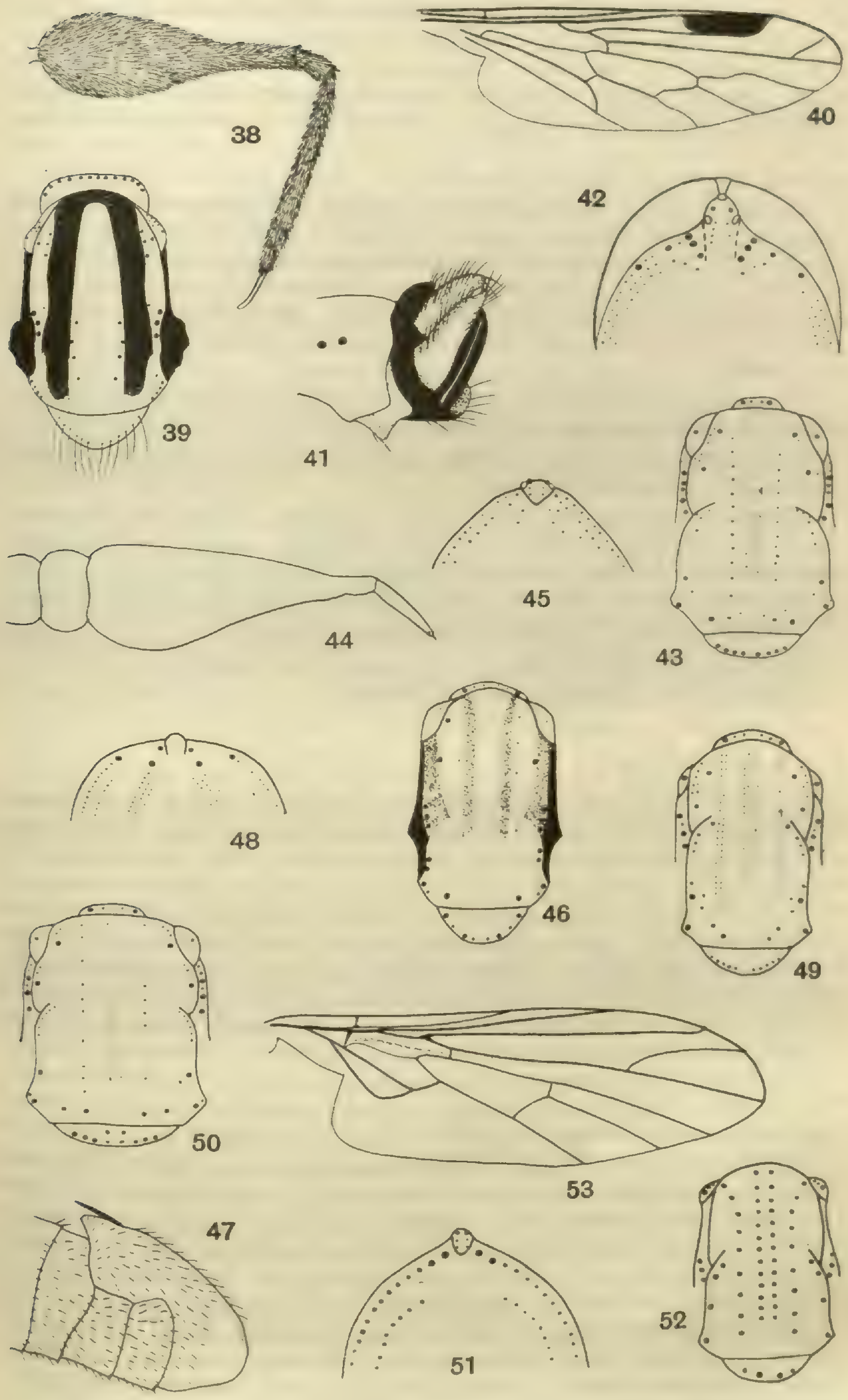
FIGS. 48, 49.—*Hilara vector* n. sp.

48. Occiput, ♂, showing chaetotaxy.
49. Dorsum of thorax, ♂, showing chaetotaxy.

FIG. 50.—*Hilaria dracophylli* n. sp.: dorsum of thorax, ♂, showing chaetotaxy.

FIGS. 51–53.—*Hilara fumosa.*

51. Occiput, ♂, showing chaetotaxy.
52. Dorsum of thorax, ♂, showing chaetotaxy.
53. Wing.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joints of antennae black but covered with grey tomentum, bristly; third joint and style shaped as in *H. flavinceris*, blackish-brown with greyish tomentum. Face black but clothed with greyish tomentum, three short delicate bristles on each side beneath each antenna. Proboscis slightly longer than head-height, dark-brown; palpi densely clothed with greyish tomentum, bristles and hairs grey. Cheeks cinereous with greyish hairs; occiput cinereous, hairy below, bristly above, among which only three pairs of bristles are distinct (fig. 48).

Thorax slightly humped, black, but clothed with cinereous tomentum except on a bare testaceous area at posterior angle of each humerus; dorsum with four longitudinal blackish stripes. Chaetotaxy weak except for alar, notopleural, humeral, and post-humeral bristles, which are outstanding; acrostichals and dorsocentrals represented by rows of numerous weak bristles (fig. 49). On scutellum is marginal row of ten erect bristles.

Wings slightly greyish, veins testaceous but paler basally, stigma slightly tawny; Sc ending in costa. Halteres tawny.

Legs testaceous; apex of tibiae and tarsi darker; anterior protarsi blackish and distinctly thickened.

Abdomen with spot-like pits on each segment; black, with cinereous tomentum; posterior margin of each segment except the first pale greyish-tawny. Genital appendage elongate, blackish-brown, but tawny along middle on each side, this colour extending over upper edge basally.

♂. Length, 6 mm.; + gential appendage, 10 mm.

Holotype: No. 954, D. M.

Habitat.—Lake Wakatipu (W. G. Howes).

H. dracophylli n. sp.

♂. Head black, but greyish-pruinose; eyes and front as in *H. flavinceris*, the latter with a row of delicate black orbital bristles; front black, with indistinct brownish area just above antennae, which are inserted in middle height of head and prominent; first and second joints shaped as in *H. flavinceris*, tawny, delicately bristled; third joint black, greyish-pruinose, elongate, clavate, terminated by a style about two-thirds its length, from the end of which projects a short, brownish chitinous spine. Face shaped as in *H. flavinceris*, black, with greyish pubescence. Proboscis about as long as head-height or a little longer, dark testaceous to dark brown, blackish at apex; palpi black with black bristles. Cheeks inconspicuous, black, with a greyish pubescence and clothed with a few delicate dark-brown hairs. Occiput convex, black but greyish-pruinose. hairy below, bristly above the system as in *H. flavinceris*.

Thorax somewhat humped, black, humeri and notopleurae testaceous with grey tomentum; alar regions testaceous; scutellum testaceous but for a small black area at base; pleurae testaceous immediately beneath wing-articulation. Chaetotaxy as in fig. 50, acrostichals bring represented by several rows of very short delicate bristles, and dorsocentrals, which are uniserial, by somewhat stronger ones. On scutellum are three pairs of strong marginal bristles, a pair of less prominent discal ones, and a pair of apical, convergent delicate bristles; in some specimens discal and apical bristles are absent. Dorsum greyish-pruinose with three indistinct longitudinal black stripes seen in some lights.

Wings hyaline except for testaceous articulation and brownish cell 2nd C and stigma; veins brown, paler basally; venation as in *H. flavinceris.* Halteres pale yellow but brownish at base.

Legs testaceous, clothed with delicate hair-like bristles; anterior protarsi slightly thickened; claws rather elongate, dark testaceous basally, black distally; pulvilli testaceous.

Abdomen dark testaceous, with testaceous markings, more or less distinct, across posterior margin of each segment except first, upon which is a triangular testaceous spot along anterior and another along posterior margin, their apices meeting in centre of segment. The whole clothed as in *H. flavinceris.* Genital appendage (fig. 2A) shaped as in *H. flavinceris*, dark-brown, with narrow tawny median stripe on each side broadening basally.

♂. Length, 6 mm.; + gential appendage, 10·5 mm.

Holotype: No. 1207, D. M.

Habitat.—New Zealand (locality and collector unknown).

H. fumosa Hutton.

Clinocera fumosa Hutton, *Trans. N.Z. Inst.*, vol. 33, p. 31, 1901.

Owing to the well-developed anal angle of the wing and the shape of the antennae, &c., this species cannot be placed in *Clinocera*, and it is doubtful if it really belongs to *Hilara*, although I have placed it therein for the present.

♂. Eyes contiguous over greater part of front, which is confined to a triangular black area with greyish reflection above antennae and to small area in front of ocellar triangle; eyes deeply emarginate; ocellar triangle black, with cinereous reflection; ocellar bristles strong but not long. Antennae black, first two joints short, bristly and yellowish-brown in some lights; third joint clavate, with greyish pubescence; terminal style slender, rather reddish brown, minutely pubescent, two-jointed, first joint very small, the whole a little longer than third antennal joint. Face short but broad, black, but greyish-white in some lights. Proboscis shorter than head-height, rather stout, blackish-brown; palpi not quite as long as proboscis, black, but greyish in some lights, and clothed with black bristle-like hairs. Occiput black, greyish in some lights, convex below, but flat above and concave medianly; among the bristles (fig. 51) is a pair of outstanding rather divergent verticals.

Dorsum of thorax black, with three longitudinal grey stripes; prothorax, incisions of transverse suture, notopleurae, humeri, and alar regions grey, this pattern being indistinct in some lights; pleurae black, with greyish reflections; metapleurae bare; a tuft of bristles above insertion of anterior coxae. Chaetotaxy of dorsum as in fig. 52. Scutellum black, but greyish in some lights, with three pairs of erect marginal bristles, pre-apical ones being weak.

Wings (fig. 53) slightly tinged with brown, veins and stigma brown; anal angle prominent; Sc meeting costa; Cu_1 and Cu_2 in one line, cell Cu being thus somewhat shorter than cell M.

Legs black, bristly, slender; tarsi normal; anterior coxae not unusually lengthened.

Abdomen elongate, narrow, cylindrical, cinereous but black in ground-colour, distinctly bristly, bristles for the most part hair-like but marginal ones stronger and larger. Genitalia inconspicuous.

♀. Eyes broadly dichoptic, head rather flat on top; front rather convex, blackish-grey; face rectangular and cinereous; proboscis shiny black, stout, curved backwards, just under twice length of head-height; a distinct pair of long, divergent ocellar bristles. Legs more or less tawny; tarsi and upper sides and middle of femora fuscous; coxae, except apex of anterior pair, cinereous-black.

♂ and ♀. Length, 6 mm.

Holotype: ♂, Hutton's collection, Canterbury Museum; ♀, No. 1212, D. M.

Habitat.—Wellington (G. V. Hudson); Otira (J. W. Campbell).

H. hudsoni Hutton.

Empis hudsoni Hutton, *Trans. N.Z. Inst.*, vol. 33, p. 30, 1901.

♂. Eyes dichoptic, deeply emarginate; occiput, front, and face black, but with cinereous tomentum brownish in some lights; fronto-orbital and ocellar bristles present. Antennae shaped as in *H. fossalis;* black, but first and second joints brownish. Proboscis a little longer than head-height, black; palpi brown. Occiput bristly, bristles arranged irregularly on each side of centre, which is bare.

Dorsum of thorax black, with a pair of indistinct brownish stripes: silvery spot on each side between humeri and wings; humeri silvery above; scutellum and alar regions along sides of dorsum to sutural incisions brownish; pleurae cinereous; metanotum brownish. Acrostichal bristles represented by four rows of short, weak bristles; dorsocentrals also weak and short but ending in two pairs of stronger bristles before the scutellum; a strong humeral bristle and numerous small ones; a pair of strong notopleurals, anterior to which are some weak ones; a strong supra-alar, posterior to which is a second one and two weak short ones; a strong post-alar; metapleurae bare; scutellar bristles consisting of four pairs, apical pair weak, pre-apical strong, remainder somewhat weaker.

Wings clear, stigma clouded; halteres brown.

Figs. 54–56.—*Hilara fossalis* n. sp.

54. Occiput, ♂, showing chaetotaxy.
55. Dorsum of thorax, showing chaetotaxy.
56. Genitalia, ♂.

Fig. 57.—*Hilara smithii* n. sp.: dorsum, ♀, showing chaetotaxy.

Figs. 58–62.—*Hilarempis fulvipes.*

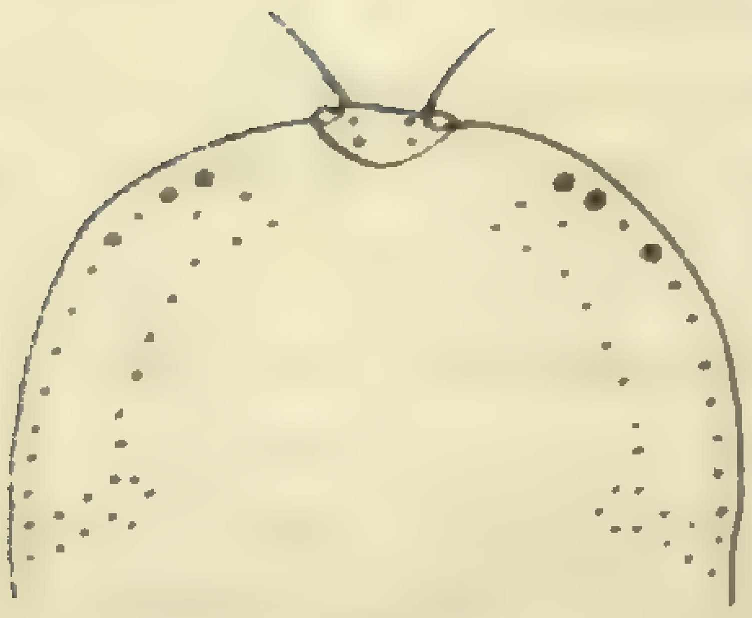
58. Antenna.
59. Dorsum of thorax, showing chaetotaxy.
60. Wing.
61. Anterior leg, ♂.
62. Genitalia, ♂.

Figs. 63–64.—*Hilarempis nigra* n. sp.

63. Dorsum of thorax, ♂, showing chaetotaxy.
64. Genitalia, ♂.

Figs. 65–68.—*Empimorpha torrentalis* n. sp., ♂.

65. Head, front view.
66. Occiput of head, showing chaetotaxy.
67. Dorsum of thorax, showing chaetotaxy.
68. Genitalia.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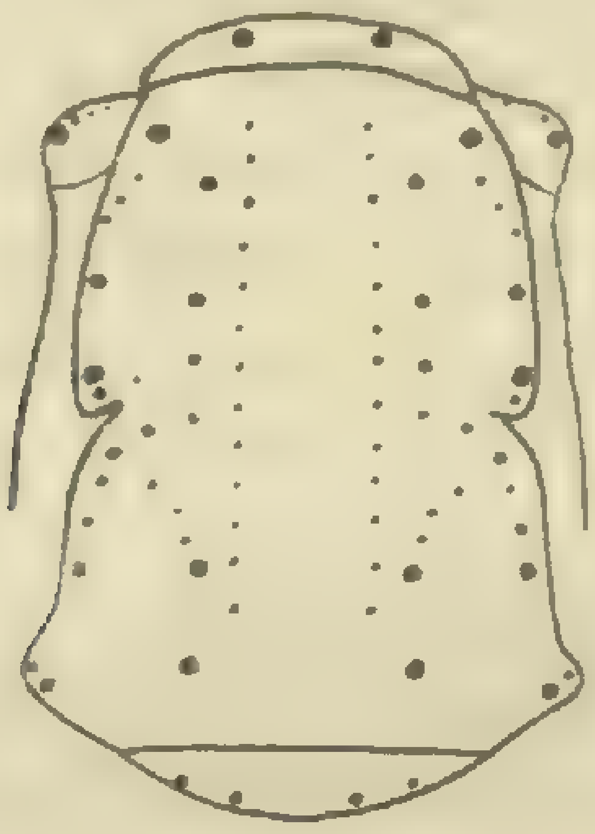
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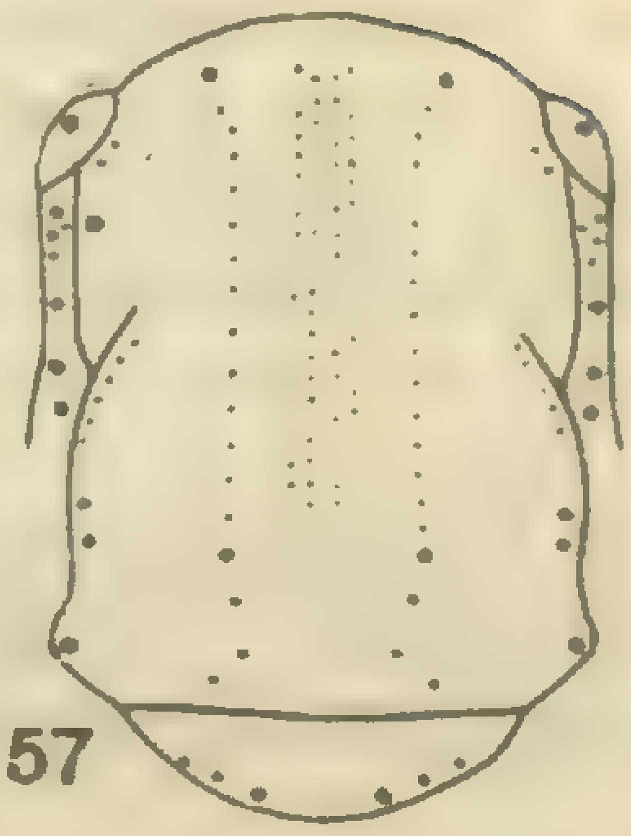
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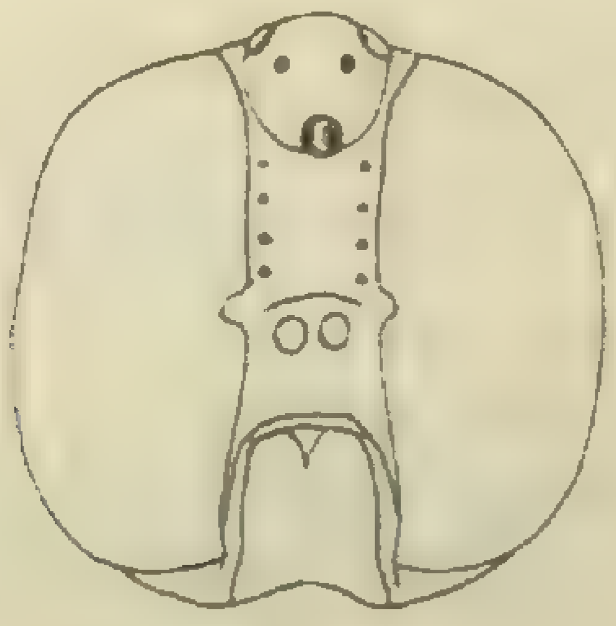
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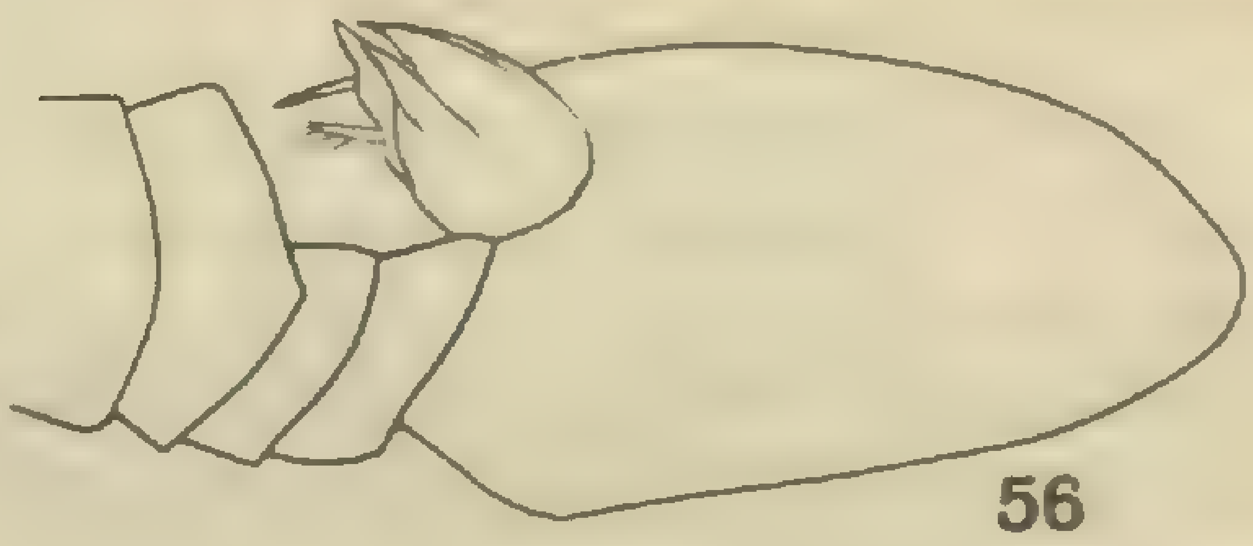
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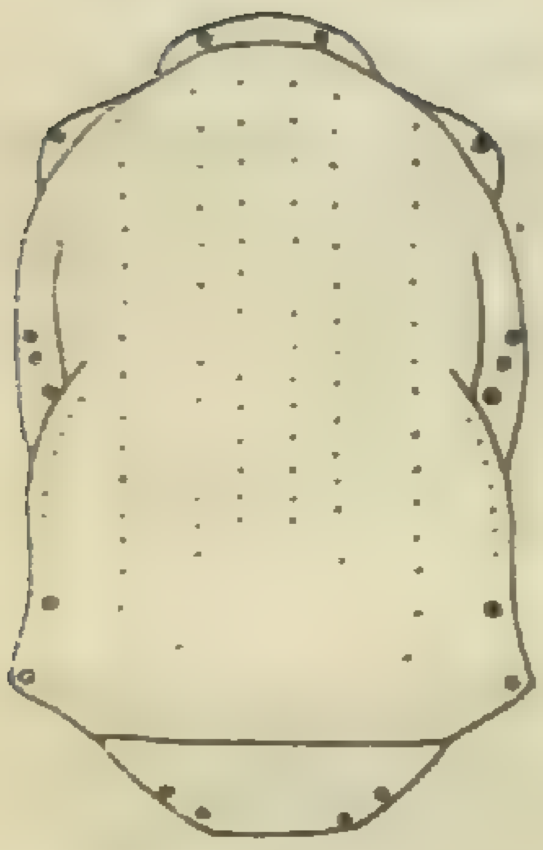
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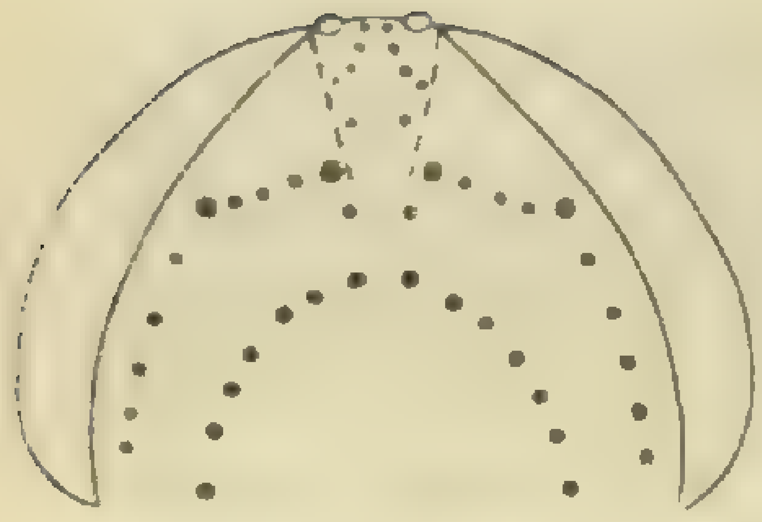
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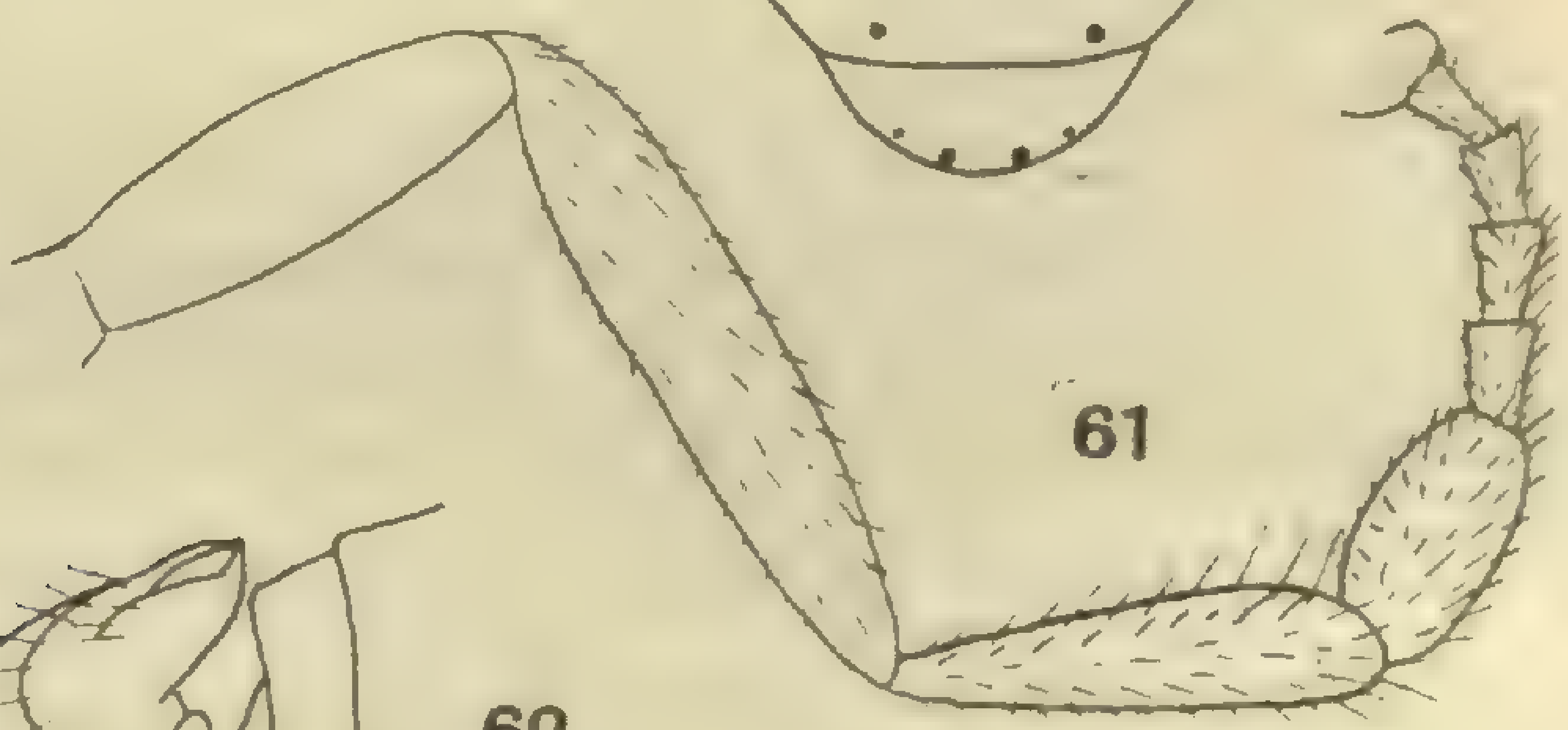
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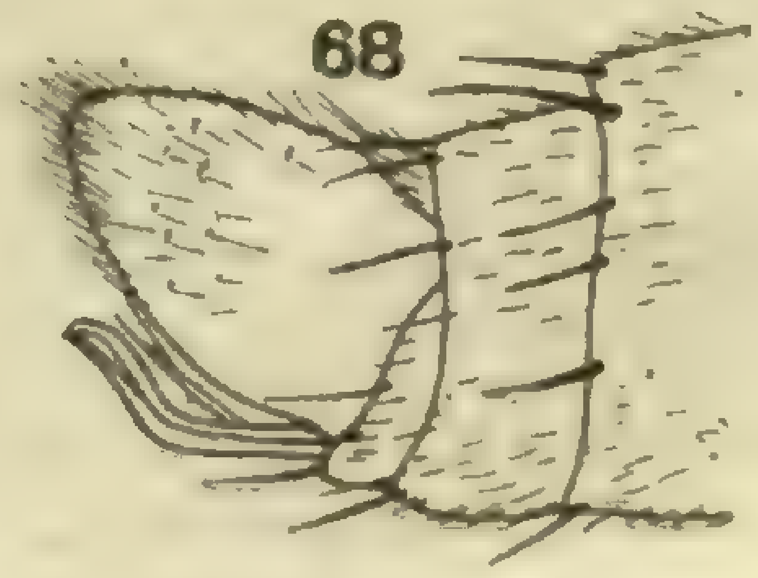
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Anterior and middle legs brownish, posterior cinereous brown to black; tarsi black; coxae cinereous; anterior protarsi enlarged.

Abdomen brownish to greyish black, clothed with very weak, short bristles; genital appendage much shorter than the abdomen, brown, the genitalia brownish-black.

♀. As male, but the abdomen conical and terminated by a pair of stylets.

♂. Length, 5·5 mm. ♀. Length, 4 mm.

Holotype: Hutton's collection, Canterbury Museum.

Habitat.—Wainuiomata; Otira Gorge (G. V. Hudson); Okere.

H. fossalis n. sp.

♂. Eyes dichoptic, deeply emarginate; ocellar triangle and front black; a pair of conspicuous ocellar bristles, behind each of which is row of small delicate ones; row of bristles on each side of front. Antennae black, inserted about middle height of head; first and second joints bristly; third joint clavate and terminated by a comparatively short style, which ends in a bristle-like appendage. Face black, with greyish reflection. Proboscis as long as head-height, brownish, but tawny along lower side; palpi black. Occiput convex at orbits, but depressed medianly; chaetotaxy, as in fig. 54.

Thorax black; the humeri, pleurae, two indistinct stripes on dorsum, scutellum, and a transverse band in front of scutellar suture greyish in some lights; metapleurae bare; chaetotaxy of dorsum distinct (fig. 55).

Wings smoky, rather short and blunt, stigma clouded; halteres brownish, heads somewhat darker.

Legs bristly inclined to tawny, upper sides of femora and tarsi black; anterior protarsi enlarged.

Abdomen black, slightly greyish in some lights, with distinct bristles towards posterior margin of each segment; genitalia prominent, brownish-black, appendage broad and not quite length of abdomen (fig. 56).

♂. Length, 4 mm.

Holotype: No. 1199, D. M.

Habitat.—Makerua Swamp, skimming over water; Ohau beach, frequenting damp sand bordering a sluggish stream.

H. smithii Hutton.

Empis smithii Hutton, *Trans. N.Z. Inst.*, vol. 33, p. 30, 1901.

♀. Head lost. Dorsum of thorax brownish-grey, with three golden stripes; chaetotaxy distinct (fig. 57); six erect marginal bristles on scutellum, three on each side, apical ones convergent; pleurae, metanotum, and scutellum cinereous; metaplurae bare. Legs tawny and bristly. Wings ochreous, inclined to translucency; R_4 branching from R_5 at an acute angle; halteres tawny.

Abdomen cinereous, ending in pair of stylets; posterior margin of each segment rather paler; the whole clothed with minute black bristles.

The type specimen, which is the only one of this species yet secured, is badly damaged, and a fuller account is not possible in consequence.

♀. Length, 5 mm.

Holotype: Hutton's collection, Canterbury Museum.

Habitat.—Ashburton (Smith).

Genus HILAREMPIS Bezzi.

Vein Sc evanescent before reaching the costa ; metapleurae bare.

TABLE OF SPECIES.

1	A tawny-bodied species ; abdomen black, with a tawny apex ..	*kaiteriensis.*
	Cinereous or blackish species	2
2	Thorax grey with four blackish-brown stripes ; abdomen dark brown ; legs brownish-black	*benhami.*
	Species with tawny legs	3
3	Body cinereous	*fulvipes.*
	Body black	*nigra* n. sp.

Provisional Table based on Chaetotaxy.

1	At least eight scutellars	*benhami.*
	At most four scutellars	2
2	Dorsocentrals altogether weak ; one pair of strong prothoracics (fig. 59)	*fulvipes.*
	Dorsocentrals ending in two or three strong bristles before scutellum ; two or more pairs of prothoracics	3
3	Three pairs of strong dorsocentrals posteriorly ; two pairs of strong prothoracics (fig. 63)	*nigra* n. sp.
	Two pairs of strong dorsocentrals posteriorly ; four pairs of prothoracics, the outer one on each side strong, the remainder weak	*kaiteriensis.*

H. benhami Miller.

H. benhami Miller, *Trans. N.Z. Inst.*, vol. 45, p. 198, figs. 1 to 5, pl. 1, fig. 3, 1913.

H. kaiteriensis Miller.

H. kaiteriensis Miller, *l.c.*, p. 200, figs. 6 to 8, pl., fig. 1.

H. fulvipes Hutton.

Hilara fulvipes Hutton, *Trans. N.Z. Inst.*, vol. 33, p. 31, 1901.

Front cinereous, but darker in some lights ; eyes deeply emarginate, dichoptic in both sexes ; row of delicate frontal bristles on each side ; ocellar triangle greyish-black, ocellar bristles present. Antennae comparatively large (fig. 58) ; first and second joints bristly and tawny, but darker at times ; third joint clavate, blackish-brown, with a somewhat lighter reflection due to greyish pubescence ; style very short. Face cinereous, owing to dense tomentum, but black ground-colour frequently reflected. Proboscis blackish-brown ; palpi tawny. Occiput cinereous, but blackish in some lights ; chaetotaxy as in *H. nigra*.

Thorax with depressed area before scutellum (which is rather truncated), brownish-grey, but cinereous at times owing to tomentum ; the black ground-colour being conspicuous particularly on pleurae. Chaetotaxy (fig. 59) mainly as in *H. nigra*, although the rows of smaller bristles are distinct, while among them are some delicate golden hairs.

Wings (fig. 60) faintly yellowish, veins and stigma tawny ; halteres tawny.

Legs tawny, with some delicate tawny bristles ; tarsi rather fuscous ; anterior coxae somewhat lengthened, their tibiae short ; anterior protarsi of the male swollen (fig. 61).

Abdomen black in ground-colour with cinereous tomentum; posterior margin of each segment with delicate bristles. Genitalia of male lying forward on abdomen (fig. 62); female abdomen ending in pair of blackish-brown stylets.

♂ ♀. Length, 3 mm.

Plesiotype: No. 1087, D. M.

Habitat.—Throughout New Zealand. Frequently seen on calm evenings dancing in swarms above bushes.

H. nigra n. sp.

♂. Eyes dichoptic, deeply emarginate, posterior margin slightly concave; front moderately wide, sides almost parallel, black, but in certain lights there is a broad silvery-grey orbital stripe on each side, leaving a narrow black medio-longitudinal one; at other times the whole front is silvery grey; a row of delicate frontal bristles on each side near orbits; ocellar triangle black; ocellar bristles distinct. Antennae large for size of head, inserted at about middle line; black, with greyish-brown reflection; minutely pubescent; first and second joints bristly, third long and clavate; style short and ending in small spine-like process. Face short, shorter than front, convex, with a few scattered delicate bristles. Proboscis blackish-brown; apical joint of palpi orange yellow to pale yellow, basal blackish-brown. Occiput black, with greyish reflection, convex (particularly above where the bristles are distinct along the orbits alone), though somewhat depressed behind ocellar triangle; chaetotaxy confined to row of orbital bristles.

Thorax black, with greyish and brownish reflections on dorsum and pleurae; a pair of very indistinct, widely separated, narrow, darker stripes on dorsum to be seen when light falls from in front. On dorsum are a few rows of indistinct delicate small bristles and a system of distinct ones (fig. 63).

Wings iridescent, veins yellow, Sc evanescent before reaching costa; anal angle distinct but not prominent; halteres pale tawny.

Legs tawny, tarsi and apices of tibiae fuscous; a row of conspicuous yellow bristles on upper side of anterior femora distally; otherwise legs not unusually bristly; anterior protarsi and apex of their tibiae only slightly enlarged.

Abdomen black, covered with short delicate bristles; genitalia black, prominent, recurved over abdomen, laterally compressed (fig. 64).

♂. Length, 3 mm.

Holotype: No. 1224, D. M.

Habitat.—Otira (J. W. Campbell), Ohau Valley; frequenting the foliage of bushes overhanging streams. Usually met with while beating.

Genus Empis Linn.

Metapleurae with hairs or bristles; proboscis as long as or longer than head-height; third antennal joint more or less elongate and clavate; face bare; vein Sc evanescent before reaching costa.

Table of Species.

An altogether cinereous species; length of ♀, 5·5 mm.	♀ *brouni.*
A blackish-grey species; length of ♀, 8 mm.	♀ *otakauensis.*

E. otakauensis Miller.

E. otakauensis Miller, *Trans. N.Z. Inst.*, vol. 42, p. 235, pl. 30, figs. 1 to 6, 1909.

In this species the palpi are normal, and not greatly elongated as stated in the original description and shown in the illustration (*l.c.*, fig. 2).

Holotype, ♂ : No. 590, D. M.

Allotype, ♀ : No. 404, D. M.

E. brouni Hutton.

E. brouni Hutton, *Trans. N.Z. Inst.*, vol. 33, p. 30, 1901.

♀. Head cinereous, the face inclined to silvery ; front broad orbits converging slightly at antennae ; row of delicate orbital bristles on each side of front ; distinct pair of ocellar bristles and shorter pair between posterior ocelli. Antennae at middle head-height ; cinereous ; first and second joints blackish in some lights and bristly ; third joint clavate and ending in a stout style not quite half length of third joint. Face short, but broader than front, silvery in some lights. Cheeks and lower part of occiput with long beard of greyish to golden hairs. Proboscis longer than head-height, blackish-brown and cinereous ; palpi cinereous to silvery and clothed with greyish hairs. Occiput cinereous to golden, with strong orbital bristles and weaker ones behind.

Thorax cinereous to golden ; a pair of blackish stripes on dorsum. Apparently no chaetae except for a pair of bristles on alar angles and a small one above the wing-base ; metapleurae with indistinct greyish hairs ; propleurae with some delicate greyish hairs. Scutellum with three pair of delicate erect marginal bristles.

Wings comparatively large, rather translucent, tinged with grey ; veins rather tawny ; R_4 branching almost at right angle from R_5, which descends somewhat from line of R_{4+5} ; Sc evanescent at apex ; halteres tawny.

Legs cinereous and bristly ; posterior tibiae broadened apically, their protarsi somewhat enlarged.

Abdomen cinereous ; apical segment triangular, blackish and bristly, particularly at apex.

♀. Length, 5·5 mm.

Holotype : Hutton's collection, Canterbury Museum.

Habitat.—Auckland (Broun).

Genus EMPIMORPHA Coqu.

This genus resembles *Empis* except that the face is hairy.

E. torrentalis n. sp.

♂. Head tawny ; eyes emarginate, dichoptic ; front almost vertical, golden in some lights, with row of short black orbital bristles on each side (fig. 65) ; ocellar triangle large, tawny to golden, a pair of large black erect and divergent ocellar bristles and numerous small ones behind (figs. 65 and 66) ; ocelli orange. Antennae conspicuous, inserted about middle head-height ; first and second joints tawny and bristly ; third joint clavate, fuscous,

except for a small tawny area at base, and clothed with minute golden pubescence; style about two-thirds as long as third joint, fuscous but with minute golden pubescence. Face (fig. 65) broad, very short, practically concealed beneath antennae, and with a few short black bristle-like hairs. Cheeks restricted, golden-tawny, and with pair of short black bristle-like hairs. Proboscis longer than head-height, descending downward, tawny; palpi tawny to golden, with long rigid black bristles on lower side but short ones apically. Occiput golden-tawny, swollen at eye-margins, chaetotaxy prominent (fig. 66).

Thorax tawny, golden-pruinose; dorsum quadrate, darker to fuscous in some lights with indistinct narrow longitudinal stripes, chaetotaxy distinct (fig. 67); metanotum brownish-black and golden-pruinose; propleurae with three black bristles and narrow black stripe above toward humeri; metapleurae with three large straight black bristles, the lower one very long; posterior to these bristles are numerous shorter and more delicate ones. Scutellum brownish-black and golden-pruinose, with three pairs of marginal bristles, the apical ones being very long.

Wings slightly tinged with tawny, stigma darker; R_4 leaving R_5 at right angle and running for one-quarter of its length before curving abruptly to costa; halteres tawny.

Legs tawny, minutely bristled and with numerous large black bristles, particularly on tibiae; none on tarsi except at apex of joints; pulvilli golden; claws tawny with fuscous tips.

Abdomen elongate, narrow, slightly tapering apically; brownish-yellow, posterior margin of each segment broadly tawny; the whole clothed with short black bristles and with large ones across posterior margin of each segment, particularly toward sides; a double row of these bristles on first segment. Genitalia (fig. 68) tawny, triangular in shape when seen from above, rather cone-shaped in profile, clothed with small black bristles, particularly at apex; the claspers tawny and elbowed.

♂. Length, 5·5 mm.

Holotype: No. 1213, D. M.

Habitat.—Waterfalls, Humboldt Mountains (G. V. Hudson).

ART. 34.—*The Leaf-mining Insects of New Zealand: Part III—Species belonging to the Genera* Agromyza (*Fallen*) *and* Phytomyza (*Fallen*) (*Diptera*).

By MORRIS N. WATT, F.E.S.

[*Read before the Wanganui Philosophical Society, 28th October, 1921; received by Editor, 31st December, 1921; issued separately, 12th May, 1923.*]

Plates 38–41.

THESE minute flies have been greatly neglected in New Zealand, only two species being quoted by Hutton*—*A. australensis* Mik. and *A. fulvifrons* Hutton. The former I have been unable to trace, and, owing to the paucity of its description, have been unable to include it in the key to the New Zealand species. The description has been placed at the end of this paper. Through the courtesy of Mr. Speight, Director of the Canterbury Museum, I have been able to examine the type specimen of *A. fulvifrons*. This was found not to belong to the genus to which it was assigned: it was sent to Monsieur Tonnoir at the Cawthron Institute, who places it in the Milichinae. T. W. Kirk has several times mentioned *P. nigricornis* (the cineraria-fly, marguerite-fly), and *P. chrysanthemani* (the chrysanthemum-fly) in the *New Zealand Journal of Agriculture*. It appears very probable that these are identical, and that it is the same fly that attacks the thistle. The latter fly was sent to the British Museum, and identified there as *P. albiceps* Mg. I have received many specimens of the younger stages of the fly mining in the cineraria in different parts of New Zealand, but have so far only succeeded in rearing parasites. In all cases *P. albiceps* was mining in thistles in close vicinity to the cineraria-plants.†

Most of the species dealt with in this paper have been under observation for several years past; fair series of the imagines have been reared from the mines, and from these good normal specimens have been selected for the types. There appears to be little variation, and in the chaetotaxy this tends in the direction of addition of setae; such addition, however, is rarely bilateral, and the additional setae are usually under-developed. Specimens of most of the species were sent to the Imperial Bureau of Entomology, British Museum, and to Mr. J. R. Malloch, of the United States Department of Agriculture, Biological Section, Washington, for verification, and I have to thank Mr. Malloch for much aid in drawing up the descriptions and in selection of the names. I should also like to thank Dr. Tillyard, of the Cawthron Institute, for much help given in these and earlier papers.

The chief generic characters of *Agromyza* as given by Mr. Malloch are—

Generic Characters of *Agromyza*.‡

"Head of normal size; frons broad, from one-third to a little over one-half the head-width; ocelli on a slightly raised portion; the ocellar

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* HUTTON, Synopsis of the Diptera Brachycera of New Zealand, *Trans. N.Z. Inst.*, vol. 33, p. 93, 1901.

† Since writing the above several specimens of *P. albiceps* have been reared from mined leaves of the cineraria.

‡ MALLOCH, A Revision of the Species in *Agromyza* Fallen and *Cerodontha* Rondani, *Annals of Ent. Soc. of America*, vol. 6, p. 269–340, 1913. See also MALLOCH, A Synopsis of the Genera of Agromyzidae, *Proc. U.S. Nat. Mus.*, vol. 46, pp. 127–54, pl. 4–6, 1913.

triangle, so distinct in the Oscinidae, seldom traceable; orbits distinct, 3–5 pairs of orbital bristles present anterior to front ocellus; one pair of bristles on ocellar region, slightly behind anterior ocellus, pointing forward and slightly divergent, vertical row consisting of two central divergent and two outer convergent bristles; post-vertical bristles divergent; face nearly straight in vertical outline, or slightly concave, slightly keeled in centre, or unkeeled; mouth-margin not produced; antennae of moderate size, or third joint enlarged, but never elongate or produced at apex; second joint with at least one dorsal setula; arista bare or pubescent, never plumose; cheeks linear or broadened posteriorly, sometimes one-half as high as eye, bristles confined to margin, vibrissa generally noticeably differentiated; proboscis membranous, not elongated noticeably nor geniculate; palpi normal. Mesonotum with 2–4 pairs of dorso-centrals; mesopleurae with 1–3 long posterior bristles as well as generally a number of setulae; one or two bristles above mid-coxae and generally numerous setulae; propleural bristle strong; squamae distinct. Ovipositor of female generally with base chitinized, apex seldom protruding; male hypopygium of moderate size, not incurved. Legs without preapical bristle on dorsal surface; end spurs weak. Wings with subcostal vein weak, sometimes incomplete, but generally complete and ending very near to first vein, or fused with first at near apex; costa at end of subcosta uninterrupted, or only slightly so; costal vein with very short hairs which are, with exception of two slightly more distinct at end of subcosta, of almost equal length to beyond middle of wing; cross-veins near to wing-base, or the outer one at, or slightly beyond, wing-middle; posterior basal cell always complete though small; anal vein (sixth) distinct; costa to third vein, slightly beyond it, or to fourth. This last character is difficult to distinguish sometimes, and is not of sufficient importance to permit of the relegation of those species having costa to only third vein to a different genus from those with costa to fourth."

The essential character of the genus *Phytomyza* as differing from the above is the entire absence of the outer cross-vein.

A rather remarkable difference in the dehiscence of the two genera (as represented in this paper) should be noticed. In a typical pupa there are two sutural lines along which splitting occurs at dehiscence,—a transverse suture extending right round the pupa about the centre of the fourth segment, and a horizontal one extending from this right round the anterior end of the pupa beneath the anterior respiratory processes; on dehiscence, therefore, the anterior three and a half segments become divided into a dorsal half (containing the anterior respiratory processes) and a ventral half, both becoming more or less separated from the rest of the puparium, the dorsal half more so than the ventral. In those pupae that pupate within the mine and extrude the anterior respiratory processes through the cuticle, the dorsal half of the anterior three and a half segments is flattened into a more or less specialized head-plate. In the genus *Agromyza* it is the dorsal plate, with its respiratory processes, that undergoes the greater amount of separation from the puparium. In the genus *Phytomyza*, on the other hand, the head-plate consists of the flattened ventral half of the anterior three and a half segments, and it is this that is lifted for the exit of the imago; and, though the anterior respiratory processes are extruded from the mine, and at first sight appear to belong to the head-plate, they are not lifted with it, but remain attached to the dorsal half.

KEY TO NEW ZEALAND SPECIES OF AGROMYZA.

1. Thorax with three pairs of strong dorso-central bristles; head, including antennae and palpi, black	2
Thorax with four pairs of dorso-centrals, the anterior two pairs sometimes much weaker than the posterior pairs	3
2. Each orbit with four strong bristles	*umbrina* n. sp.
Each orbit with three strong bristles	*umbrinella* n. sp.
3. Femora largely or entirely black or fuscous	4
Femora largely or entirely pale yellow	6
4. Anterior two pairs of dorso-centrals much weaker than posterior pairs; penultimate section of fifth wing-vein not half as long as ultimate	*flavolateralis* n. sp.
Anterior two pairs of dorso-centrals but little weaker than the posterior pairs; penultimate section of fifth wing-vein over half as long as ultimate	5
5. Scutellum broadly yellow; three orbital bristles	*flavocentralis* n. sp.
Scutellum obscurely greenish-grey; four bristles to each orbit..	*umbrosa* n. sp.
6. Scutellum almost entirely pale yellow, only blackened on sides; penultimate section of fourth wing-vein not over one-third as long as ultimate section of fifth	7
Scutellum almost entirely glossy black, only the anterior lateral angles slightly yellowish; penultimate section of fourth wing-vein at least half as long as ultimate section of fifth ..	8
7. Each orbit with four strong bristles	*citreifemorata* n. sp.
Each orbit with three strong bristles	*clianthi* n. sp.
8. Pleura yellow, with a large blackish spot on sterno-pleura and a smaller one above hind coxa	*flavopleura* n. sp.
Pleura entirely yellow	*flavopleura* var. *casta* n. var.

(13.) **Agromyza umbrina** n. sp. (The Veronica Blotch-fly).

The Imago.

Male. Frons more than half the width of the entire head, dark grey to black with a slight yellowish tinge; antennae, palpi, genae, occiput, and ocellar triangle black; proboscis yellowish; eyes dark red-brown; each orbit with four strong bristles; ocellar and post-vertical bristles strong; arista pubescent.

Thorax black, shining; lateral margins in front of wing-bases yellowish; four to six series of setulae between the three pairs of dorso-centrals; prescutellar acrostichals absent; scutellum entirely black.

Abdomen dark greenish-grey to black, shining; ventro-lateral margins obscurely yellowish; under-surface lighter grey tinged with yellowish.

Legs black; upper joint of tarsus paler.

Wings (fig. 21) greyish, bases yellowish, veins black. Costa to apex of fourth vein, the latter ending in the tip of the wing; penultimate section of fourth vein about one-sixth as long as ultimate, and one-fourth as long as ultimate section of the fifth. Halteres lemon-yellow.

Female similar to male, slightly larger.

Length, about 2·5 mm. (♂).

Type in author's collection; reared from mines obtained in Botanical Gardens, Dunedin.

Distribution.

At present only recorded from Dunedin, where it is fairly common. Imagines easily reared from the mines, but more easily caught while resting on the leaves of the food-plant; the younger leaves and young buds are the most favoured situations in which to find the flies ovipositing and feeding. To be found throughout the summer months; there may be

three to four generations. Imagines found in the greatest numbers during February, April, October, and December.

Easily distinguished from *A. flavocentralis*, also common on the same food-plant, by its darker colour, and especially by absence of yellow spot on the scutellum, which in the latter species is a most conspicuous mark.

Food-plants.

Has been reared from *Veronica speciosa*, *V. salicifolia* (koromiko), and a number of the larger-leaved hybrid veronicas.

Egg-laying and Larva.

Ova laid singly and deposited in minute pockets under cuticle of the leaf. Youngest leaves most favoured. No fixed situation on the leaf, though majority of pockets constructed in vicinity of midrib, and practically invariably on underside of leaf, this, of course, being the outermost and only available surface in the buds, which are the favourite site for oviposition. Duration of egg stage not known; possibly not longer than a fortnight.

Full-grown larva about 4 mm. in length, yellowish-green, shiny. First moult takes place in preliminary gallery on underside of leaf; second moult normally about 6 mm. along the mine on upper side of leaf. Pharyngeal skeleton fairly stout; number of teeth on mandibular sclerite in all three instars is two. Length of pharyngeal skeleton, exclusive of mandibular sclerite—first instar, 0·20 mm.; second instar, 0·30 mm.; third instar, 0·43 mm. Length of mandibular sclerite—first instar, 0·03 mm.; second instar, 0·05 mm.; third instar, 0·08 mm.

The Mine. (Plate 38, fig. 3; Plate 40, fig. 6.)

Mine is a composite one, consisting of gallery and blotch. Gallery portion mainly situated on under-surface of leaf; narrow and so closely looped back and forth that the various portions eventually anastomose and form a false blotch; this part of the gallery may be 4–7 cm. in length, but owing to looped character the false blotch will rarely exceed 1·5 cm. in length; direction is in the long axis of leaf, and mine usually close against midrib; colour pale green, earlier parts whitish; frass scanty, very fine, scattered. Many larvae spend the winter months in this preliminary part of the mine.

Larva sooner or later leaves under-surface and mines close up against upper cuticle, the mine rapidly widening so as to form eventually a pear-shaped blotch. Margins shallowly dentate. Average size of blotch—length, 2·5 cm.; greatest diameter, 1·25 cm. Direction of blotch, as a rule, from region of midrib towards apex of leaf; midrib does not form a serious obstruction to this part of mine. Blotches most commonly found in central third of leaves. No indication of blotch on underside of leaf, excepting, of course, preliminary gallery; on upper surface the colour rapidly becomes dark brown or grey, in fresher portions dark green in centre and pale around margin. Cuticle over blotch becomes crinkled and mine has appearance of being slightly inflated. "Herring-boning," caused by larva's habit of feeding (see Plate 38, fig. 3), very marked. Frass coarse, of semi-fluid consistency, relatively scanty, deposited mostly on roof of mine in track of larva. In larger leaves several mines occupy same leaf, but galleries and blotches of different larvae never anastomose.

The Pupa. (Plate 38, fig. 4; text-figs. 11, 12.)

Pupation, consisting of hardening of larval skin, takes place within blotch-mine, and, except for a short white thread extending from anal aperture to floor of mine, pupa lies free within blotch. Dorsum of pupa evenly rounded, greatest height about middle; segments well rounded and become narrowed cephalad, practically devoid of sculpture, but bear four or five rows of very minute spines on sides anteriorly; just below mid-lateral line each segment slightly prominent anteriorly, an obscure shoulder being thus formed; in mid-dorsal line segments are somewhat hollowed cephalad. Anterior respiratory processes short and set close together on small prominence; they project almost directly upwards and outwards, are expanded at tips, and are slightly overhung by first segment; second segment tends to overhang first, and the next to last segment is prominent posteriorly. Posterior respiratory processes relatively large and prominent, mushroom-shaped; below them last segment bluntly prominent and shows the slightly sunken anal aperture. Colour of pupa rich dark brown, assuming a black colour prior to emergence of fly, due to dark colour of this latter; empty pupa-cases a rich golden-brown.

Average dimensions: Length, 2·6 mm.; greatest dorso-ventral diameter, 1·2 mm.; greatest lateral diameter, 1·45 mm.

On dehiscence dorsal halves of first three and a half segments lift up in one piece, ventral halves of same segments also break away in one piece around transverse suture. Both plates, however, remain more or less attached to puparium by pieces of membrane. Emergence of fly has not been observed, and it is difficult to understand just how it is done: it is known that it emerges by means of a short slit in upper surface of leaf at margin of blotch; possibly this slit is prepared by larva, but no sign of it has been found in mines from which flies had not yet emerged.

Duration of pupal period, about thirty days, normally.

(14.) **Agromyza umbrinella** n. sp. (The Minute Veronica Blotch-fly).

The Imago.

Male. Head black; frons with obscure greyish tinge; proboscis obscurely yellowish; eyes dark red-brown; each orbit with three strong bristles; ocellar and post-vertical bristles strong and of nearly equal size.

Thorax—dorsum black; three pairs of strong dorso-central bristles, the setulae between them sparse, and arranged in three or four irregular series; pleural sutures obscurely yellowish; lateral margin of thorax in front of wing-bases obscurely yellowish; scutellum black, obscurely greyish in centre.

Abdomen dark grey; tergites tinged with yellowish posteriorly; sides and under-surface yellowish.

Legs black.

Wings (fig. 22) dark grey, veins black. Penultimate section of fourth vein about one-eighth the length of the ultimate, and about one-fifth as long as ultimate section of the fifth; halteres lemon-yellow.

Length, 1·5 mm.

Type in author's collection; bred from mines from Woodhaugh Gardens, Dunedin.

Distribution.

First discovered in Woodhaugh Gardens, Dunedin, 29th June, 1919, by Mr. W. G. Howes. Not by any means a common fly, and specimens

have only been procured by rearing from the mines. Has been found on Swampy Hill, Dunedin; and I have found the mines at an elevation of 3,000–5,000 ft. on north and south sides of Mount Ruapehu in January, 1921 and 1922 (scarce). In Dunedin imagines have emerged towards end of March, and during September.

Food-plant.

Veronica Colensoi.

Egg-laying and Larva.

Eggs laid singly in minute pockets beneath under-cuticle of leaf. From examination of large number of specimens position of egg-pocket appears constant—close against outer margin of leaf and about 3 mm. from apex.

Full-grown larva about 2 mm. in length, pale greenish-orange, shiny. Particulars of stadia and duration of larval existence unknown. Pharyngeal skeleton of final instar 0·35 mm. long, exclusive of mandibular sclerite; this latter process possesses two teeth, its length being 0·07 mm.

The Mine. (Plate 40, fig. 7.)

Course of mine very constant, direction at first being along margin of leaf towards apex; here, crossing midrib, it continues down opposite margin towards base. From egg-pocket to midrib, gallery narrow and expanding but little; then, however, widening rapidly so as soon to occupy whole of one-half of leaf. Margins of gallery minutely irregular. Up to this time mine entirely on underside of leaf, there being no evidence of it on upper; larva now commences to mine close under upper cuticle and excavates a blotch, which, as a rule, includes entire upper surface of leaf; occasionally only half leaf may be blotched, and in such cases it is usually distal half. Midrib is no barrier to progress of blotch. Frass relatively plentiful, black, semi-viscid, and in gallery forms a more or less unbroken expanding central band; in blotch it is distributed more haphazard. Early part of mine pale green with darker centre and almost white margins; in older blotches containing pupae entire upper surface of leaf more or less rich grey-brown, paler and with yellowish tinge around margin. Completed mine has characteristic inflated appearance, as though the leaf had been blown out. Average length of gallery, 1 cm.; average area of blotch, 20 sq. mm. Discoloration of leaf does not extend beyond boundaries of mine. Never more than one mine in a leaf.

The Pupa. (Figs. 3 and 4.)

Larva pupates within blotch-mine, where, except for short thread attaching its posterior end to floor of mine, it lies free. Colour at first whitish, rapidly becoming jet-black. Though smaller, it is very similar to that of *A. umbrina.*

Average dimensions: Length, 1·86 mm.; greatest ventro-dorsal diameter, 0·76 mm.; greatest transverse diameter, 1 mm.

Duration of pupal existence doubtful—possibly not longer than thirty days under normal conditions. Only one record in my notebook: four larvae pupated 16th July, 1919, and imagines emerged 10th August, 1919 = twenty-five days. Dehiscence similar to that of *A. umbrina*, and fly escapes from mine by means of minute slit in side of leaf near base.

(15.) **Agromyza flavolateralis** n. sp. (The Whiteywood-fly).

The Imago.

Male. Frons about one-third width of head, yellow; ocellar triangle black; antennae orange, arista pubescent, black; proboscis, palpi, and genae yellow; occiput black; eyes dark brown; each orbit with four bristles; ocellar bristles shorter than post-vertical pair.

FIG. 1.—*A. flavopleura*, pupa, lateral view.
FIG. 2.—The same, dorsal view.
FIG. 3.—*A. umbrinella*, pupa, lateral view.
FIG. 4.—The same, dorsal view.
FIG. 5.—*A. clianthi*, pupa, lateral view.
FIG. 6.—The same, dorsal view.
FIG. 7.—*A. citreifemorata*, pupa, lateral view.
FIG. 8.—The same, dorsal view.
FIG. 9.—*A. flavolateralis*, pupa, lateral view.
FIG. 10.—The same, dorsal view.
FIG. 11.—*A. umbrina*, pupa, lateral view.
FIG. 12.—The same, dorsal view.
FIG. 13.—*A. flavocentralis*, pupa, lateral view.
FIG. 14.—The same, dorsal view.
FIG. 15.—*P. climatadi*, pupa, lateral view.
FIG. 16.—The same, ventral view.
FIG. 17.—*P. albiceps*, pupa, lateral view.
FIG. 18.—The same, ventral view.
FIG. 19.—*A. umbrosa*, pupa, lateral view.
FIG. 20.—The same, dorsal view.

(Camera-lucida sketches; all to same scale.)

Thorax black, shining; lateral margins in front of wing-bases, and sutures of pleura, broadly greenish-yellow; scutellum obscurely pale in centre; two strong posterior and two weak anterior pairs of dorso-centrals.

Abdomen very dark grey to black; ventro-lateral margins narrowly light grey-greenish.

Legs dark with knee-joints and bases of tarsi paler, yellowish.

Wings (fig. 23) greyish, veins fuscous; calyptrae grey, fringes fuscous; costa to apex of fourth vein, the latter ending in tip of wing; penultimate section of the fourth vein about one-tenth as long as ultimate. Halteres pale yellow.

Length, 2 mm. Female slightly larger than male, but otherwise similar.

Type in author's collection; reared from mines obtained in Botanical Gardens, Wellington.

Distribution.

First discovered in Botanical Gardens, Wellington, 22nd June, 1919. Fairly plentiful in Wellington, and has also been found in Wanganui district. Not yet found in South Island. Imagines appear in October and November.

Food-plant.

Melicytus ramiflorus (mahoe, whiteywood).

Egg-laying and Larva.

Ova laid singly in minute pockets beneath under-cuticle of leaf, generally in vicinity of midrib, in distal half of leaf.

Full-grown larva—length, 3 mm.; pale green, shiny, darker posteriorly with touch of yellow; cylindrical, bluntly rounded caudad, slightly attenuated cephalad; respiratory processes black. Larva undergoes three stadia, duration of which are not known, but situations of moults in mine are given in next paragraph. Mandibular sclerite possesses but two teeth in all three instars. Larval existence of about twenty-one days' duration. When fully fed it cuts a semicircular slit in upper epidermis of leaf at end of mine and pupates amongst vegetation near or on ground. In breeding-dishes larvae always pupated under cover of leaves, and pupation occurred within a few hours of emergence from mine; in dishes provided with fine sand and earth many of larvae pupated on surface of this, but never penetrated into it. Pupation has never been found to take place within mine.

The Mine. (Plate 41, figs. 3, 4, 5.)

Mine a conspicuous white or pale-green gallery on upper side of leaf. Entire mine is close under upper cuticle, first 3 cm. or 4 cm. being much closer against cuticle than the rest, and consequently white in colour and slightly more conspicuous. After second moult, which occurs when mine is about 3 cm. long, colour of fresh mine is pale green, owing to larva mining deeper and thin layer of leaf-substance intervening between mine and cuticle. No discoloration of leaf external to mine. Gallery widens evenly from about 0·5 mm. at start to 3–4 mm. at termination; margins are shallowly scalloped; direction more or less erratic and angulated owing to tendency to follow coarser veins of leaf—at times mine may be much looped upon itself, and may send out short blind branches. Where portions of later gallery happen to cross first 2 cm. or 3 cm. they do not anastomose, later portion passing beneath earlier. General trend of mine is in long axis of leaf, and midrib is rarely crossed except by later portion of mine, and then usually only in distal third. First moult occurs at a point about 1 cm. from start; positions of moults easily found by holding leaf up against light and searching for cast pharyngeal skeleton with hand-lens; where these casts are found it will be noticed that in immediate vicinity there is less frass than elsewhere, and mine at this point may be slightly enlarged

on one side. Roof of mine slightly domed over larva. Frass deposited in semi-viscid state, scanty, dark green to black; in early part of mine it occurs in two thin parallel more or less interrupted lines of minute granules along sides of gallery; later deposits are larger and more or less smeared over roof of mine, and are usually placed alternately towards first one side of mine and then the other. "Herring-boning" very plain. Under adverse conditions, as when leaves are picked while larvae still very young, there is a tendency for mine to become longer than normal, more tortuous, branching, and deeper in tissues. Colour of mine on underside of leaf a shade paler green than elsewhere, and but for this there is little evidence of it here. Rarely more than two or three mines in any one leaf. Average length of mine about 9 cm. Mines should be looked for during September.

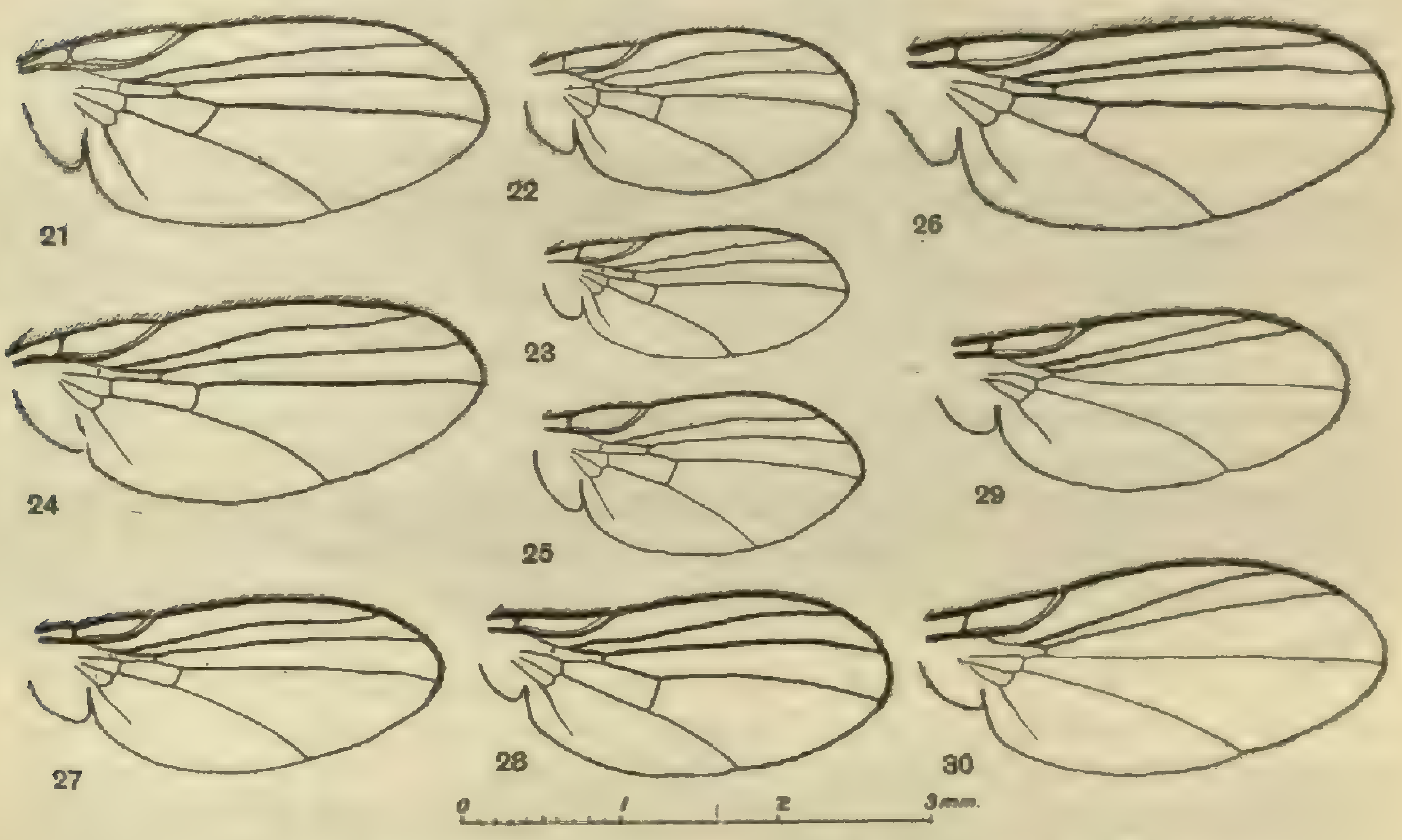

FIG. 21.—*A. umbrina.*
FIG. 22.—*A. umbrinella.*
FIG. 23.—*A. flavolateralis.*
FIG. 24.—*A. flavocentralis.*
FIG. 25.—*A. umbrosa.*
FIG. 26.—*A. citreifemorata.*
FIG. 27.—*A. clianthi.*
FIG. 28.—*A. flavopleura.*
FIG. 29.—*P. albiceps.*
FIG. 30.—*P. clematadi.*

(Camera-lucida sketches; all to same scale.)

The Pupa. (Figs. 9, 10.)

Formed by hardened larval skin. At time of pupation larva ejects all unutilized food-material in form of a green fluid, and this serves to cement puparium to its support. Colour of pupa grey-brown; in some instances almost jet-black, due as a rule to presence of a parasite. Dorsum somewhat humped in region of fifth and sixth segments; cephalic extremity bluntly pointed; laterally anterior segments are slightly expanded about mid-lateral line to form on either side of puparium a bluntly-rounded ridge or shoulder bearing the horizontal suture. Anterior respiratory processes situated close together dorsal to suture; they are short, with small black expanded tips, and directed upwards and forwards. Segments moderately rounded, narrowed cephalad, marked with minute annular striae, and minutely pitted in intersegmental regions; dorsum of each segment bears a shallow pit in mid-line close against caudal margin. Last segment large; postero-dorsally it bears posterior respiratory processes, which are directed

backwards, and are stouter and farther apart than anterior pair, but, like these latter, have black expanded tips; below and lateral to post-respiratory processes is a small prominence on either side, and between and below these is situated the posterior aperture.

Average dimension: Length, 1·86 mm.; greatest transverse diameter, 1·04 mm; greatest height, 0·89 mm.

Duration of pupal period normally eighteen days. Dehiscence similar to that of other species already described.

(16.) **Agromyza flavocentralis** n. sp. (The Veronica Gallery-fly).

The Imago.

Male. Eyes dark reddish-brown; occiput and ocellar triangle black; frons lemon-yellow; area at base of antennae, scape, pedicel, and arista black, terminal segment orange; clypeus black; proboscis and genae lemon-yellow, palpi darker; three strong bristles along each orbit (some specimens possess a fourth weak pair below); ocellar bristles as long as post-verticals.

Thorax black, shining; dorso-lateral margin in front of wing-base yellow, pleura very narrowly yellow on sutures; setulae between dorso-centrals long and sparse, forming 3–4 irregular series; anterior two pairs of dorso-centrals weaker than the two posterior pairs; scutellum broadly yellow in centre from base to apex.

Abdomen black; intersegmental incisions showing pale-yellowish when abdomen is distended; ventro-lateral margin pale-yellowish.

Legs black; apices of femora yellow, first three joints of tarsi darker yellow.

Wings (fig. 24) pale-greyish, veins black; penultimate section of fourth vein as long as ultimate section of fifth, penultimate section of fifth vein over one-half as long as ultimate. Halteres yellow.

Length, 2·75 mm. Female slightly larger than the male.

Type in author's collection; reared from mines obtained in Botanical Gardens, Dunedin.

Distribution.

Appears to be widely distributed. First found on Mount Egmont, at 3,000–4,000 ft. (common), January, 1917, and again in April of same year. Has also been found since at Wanganui, Wellington, and Dunedin (common). Mr. Tapley has sent me mines from Governor's Bay, and reports it common about Christchurch. Mr. C. C. Fenwick secured mines on Milford track in January, 1921. Imagines may be caught on food-plant throughout summer months.

Food-plants.

Veronica salicifolia (koromiko), *V. speciosa*, and a large number of the larger-leaved hybrid veronicas.

Egg-laying and Larva.

Ova laid singly in small pockets beneath under-cuticle of leaf, most usually in proximal half. Duration of egg stage possibly not longer than a fortnight under favourable conditions. Egg-pockets soon become discoloured, dark brown to black, and are then very conspicuous on both surfaces of leaves; they can easily be distinguished from similar spots caused by blight by the small transparent centre. They are often to be

found in short series, half a dozen or so, and none of these may contain an ovum; they have been made by the same individual for purposes of refreshment only, the exuding sap from the freshly punctured hole being eagerly sucked up. The majority of the "egg-pockets" are really constructed for this purpose—apparently a common habit among most leaf-mining flies.

Full-grown larva—length 4 mm., pale-yellowish anteriorly, dark green posteriorly, shiny. Larval existence from two to four weeks under favourable conditions. Number of instars three; number of teeth on mandibular sclerite in each instar two. Length of pharyngeal skeleton, exclusive of mandibular sclerite—first instar, 0·18 mm.; second instar, 0·25 mm.; third instar, 0·37 mm. Length of mandibular sclerite—first instar, 0·05 mm.; second instar, 0·08 mm.; third instar, 0·1 mm. First moult occurs at a point in mine about 1·5 cm. from start, second moult about 5–6 cm. from start.

The Mine. (Plate 38, fig. 1; Plate 40, figs. 1–3, 5.)

A long, narrow gallery, margins practically parallel except in last two or three centimetres, where mine widens considerably and margins become irregular and scalloped. Mine close against upper cuticle of leaf throughout its whole extent; little indication of it on under-surface, but above it is most conspicuous. Course irregular and serpentine, frequently markedly vermiform in character, contiguous loops running so close as almost to form a blotch of the whole. Total length of mine averages about 14 cm. First one or two centimetres frequently closely looped around egg-pocket and would appear to be wound spirally round it for six or seven turns, and in some of the larger fleshy-leaved veronicas this is actually the case. "Herring-boning," caused by the manner of feeding, is a very marked characteristic (see Plate 38, fig. 1), and makes the mine a most beautiful object when viewed by transmitted light with the low powers of a microscope. In the long narrow-leaved veronicas it is usual to find gallery following margin of leaf very closely; midrib forms a barrier in its proximal two-thirds. Occasionally gallery is closely looped upon itself across one-half of leaf, and area is just saved from being a blotch through intervening walls between the loops not being broken down; this type of mine frequently occurs when egg has been laid in vicinity of tip of leaf. Mine conspicuous on account of its dark colour, the cuticle covering it rapidly dying and becoming brown, and the frass showing darkly through it all along, causing the mine in its freshest portion to appear a darker green than surrounding leaf-surface. Frass not abundant; very dark green when fresh, but rapidly becomes black; deposited in a semi-fluid form, and occupies one or other side of mine in an interrupted line of small particles which adhere chiefly to roof of gallery. Frass-line does not keep to same side of mine throughout its length, but alternates in longer or shorter lengths, first on one side and then on other; where the mine is closely looped frass-line may occupy left side along one length and right side in next, this being due to the fact that the larva mines upon its side, and when it makes a sudden change of direction it has to turn over upon the opposite side, by so doing avoiding doubling upon itself in a narrow passage. Seldom more than one mine in a small leaf, though a large leaf may contain two or three. When full-grown, larva emerges by semicircular cut in epidermis of leaf at end of mine; in almost every case escape is made through roof of gallery. Position of moults can easily be found as before.

From an examination of the mines it would appear that there is a distinct variety of this fly, for the following constant type has often been found. Mine a rapidly-widening pear-shaped gallery (see Plate 40, fig. 5), very dark coloured at apex and in central portion and pale along margins. Frass deposited in central line only, except in very early part, where there is tendency for it to be in two rows. "Herring-boning" occurs transversely across mine in close outwardly convex curves. Margin of mine slightly scalloped. Frequently terminal centimetre or so considerably narrower than middle portion. Average length of mine 4–5 cm., greatest average width 8 mm. Larva almost invariably escapes from mine through lower cuticle. Larvae slightly heavier built with a somewhat heavier pharyngeal skeleton than the long narrow-gallery type; pupae darker in colour and slightly larger, and in the breeding-jars were far less securely attached to their support. The mine, however, is a very distinct feature. A long series of both flies have been reared, but superficially show no differences, so one hesitates to go further at present than simply state the facts.

The Pupa. (Figs. 13, 14.)

After emerging from the mine, larva pupates on or near ground; in breeding-jars larvae never penetrated beneath surface of sand. Pupa is pale amber in colour; dorsal outline well rounded; segments moderately rounded, shiny, unsculptured, possessing microscopic spines cephalo-laterad, slightly produced cephalad in mid-dorsal line. Antero-lateral "shoulder" not well developed. Anterior spiracles short, black, and relatively close together; posterior stout, black, on strong tubercles, and relatively wide apart. Posterior ventro-lateral tubercles well marked. Anal aperture on a small elevation ventrad.

Average dimensions: Length, 2·41 mm.; greatest ventro-dorsal diameter, 1·17 mm.; greatest transverse diameter, 1·21 mm.

Duration of pupal stage: The following dates are from my field-book: Larvae pupated 6th January emerged 30th January = 24 days; 1st July to 30th August = 60 days; 20th March to 28th April = 39 days. Dehiscence identical with that of species already described.

(17.) **Agromyza umbrosa** n. sp. (The Small Veronica Gallery-fly).

The Imago.

Male. Frons and genae green-yellowish, covered with a minute black pubescence; eyes dark-reddish; occiput, ocellar triangle, antennae, and palpi black; each orbit with four strong bristles, the lower two convergent across the face, the upper two erect; ocellar bristles as long as or slightly longer than the post-verticals; arista pubescent; third joint of antennae as long as second; proboscis greenish-yellow.

Thorax black, shining; lateral margins in front of base of wings, and pleural sutures, greenish; scutellum with an obscure broad antero-posterior band of greenish-grey; four series of setulae between the four pairs of dorso-centrals; anterior two pairs of dorso-centrals only slightly weaker than the posterior two pairs.

Abdomen very dark grey to black on dorsum; posterior margins of tergites greenish; sides yellowish-green; under-surface dark grey with yellowish-green intersegmental regions.

Legs entirely black.

Wings (fig. 25) pale-greyish, veins darker grey; ultimate section of fourth vein eight and a half times as long as penultimate section, the latter one-fifth as long as ultimate section of the fifth; penultimate section of fifth two-thirds as long as ultimate. Halteres very pale lemon-yellow.

Length, 2 mm.; length of wing, 2 mm.

Type in author's collection; reared from mines obtained in Botanical Gardens, Dunedin.

Distribution.

Has only been found in the Botanical Gardens, Dunedin. Larvae starting mining in early November started to pupate beginning of December, imagines emerging about 22nd December.

Food-plant.

Apparently confined to *Veronica monticola.*

Egg-laying and Larva.

Egg laid in a small pocket under lower cuticle of leaf, almost invariably within 1 mm. of extreme tip and about half-way between midrib and outer margin.

Full-grown larva, length 3 mm.; yellow in anterior half, dark green posteriorly, shiny. Larvae have been found mining in February, March, and November.

The Mine. (Plate 40, fig. 4.)

A simple gallery, varying in length from 2·5 cm. to 4 cm. Larva, on hatching, mines at once to upper surface of leaf, and thenceforth mines closely under upper cuticle. At first the gallery closely follows outer margin of leaf as far as its basal quarter, and then turns back between its previous course and midrib, which forms a barrier till larva is fairly matured; enclosed between these narrow limits practically all the leaf-substance between the two cuticles is removed; soon the larva is able to break through midrib, generally near apex of leaf, and continues mining in opposite half, there being no indication of this portion of mine on the underside of leaf. Gallery usually terminates about half-way down leaf, occupying entire width of this half between midrib and margin. Colour of mine very dark brown, lighter around margins; dark green over terminal part while fresh, very dark towards middle owing to frass. "Herring-boning" not very marked. Fresh mines appear somewhat swollen and stand out in relief. Frass black, rather scanty, deposited in a semi-fluid condition on both floor and roof of mine. In the narrow gallery at start it occupies two thin more or less interrupted lines, one on either side of mine, close to margin; this double formation is practically lost in later wider gallery. Never more than one mine found in a leaf. When full-grown, larva makes escape through upper or lower cuticle indiscriminately.

The Pupa. (Figs. 19, 20.)

Pupation normally occurs on or in ground, but not more than ¼ in. below surface. Colour of pupa pale to dark brown. Dorsum rounded; ventral surface almost flat; anterior end directed more ventrad than dorsad, bluntly pointed in lateral profile.

Anterior respiratory processes short, slender, knobbed, almost as far apart as posterior pair, which are stouter with black expanded ends. Segments well rounded, shiny, covered with fine annular striae; very fine

and minute spines in intersegmental regions. Posterior ventro-lateral tubercles very prominent, can be seen in dorsal profile. Ventral aperture slightly prominent. Antero-lateral shoulder well pronounced as far back as transverse suture. Dehiscence as in other species already described.

Average measurements: Length, 2·4 mm.; greatest ventro-dorsal diameter, 1·1 mm.; greatest transverse diameter, 1·3 mm.

Average length of pupal existence, three weeks in normal conditions.

(18.) **Agromyza citreifemorata** n. sp. (The Ngaio-fly).

The Imago.

Male. Frons, palpi, and genae lemon-yellow; antennae orange, arista pubescent, black; ocellar triangle and occiput black; eyes dark blackish-brown; each orbit with four bristles; ocellar and post-vertical bristles of about equal length.

Thorax—dorsum black, faintly shagreened; lateral margins of mesonotum broadly yellow, pleura with sutures and upper margin broadly yellow; four pairs of dorso-central bristles, anterior pair weak; about six irregular series of setulae between dorso-centrals; scutellum bright yellow in central two-fourths.

Abdominal tergites black, with very narrow yellow posterior margins; ventro-lateral areas yellow, under-surface black.

Legs lemon-yellow; tibiae brownish medially.

Wings (fig. 26) clear, veins brown, yellow at their bases; fringes of calyptrae fuscous. Halteres yellow. Last section of fifth vein twice as long as preceding section and four times as long as penultimate section of fourth vein.

Length, 3 mm. Female similar to male, with exception of being slightly larger.

Type in the author's collection; reared from mines obtained in St. John's Hill Reserve, Wanganui.

Distribution.

First discovered in St. John's Hill Reserve, Wanganui, 21st June, 1917, and has been found there every year since. Botanical Gardens and Tomahawk Lagoon, Dunedin (common). Mines have been sent to me by Mr. Tapley from Governor's Bay, Christchurch (scarce). Although widely distributed, by no means common except in restricted localities. Imagines appear in September, November, and January.

Food-plant.

Myoporum laetum (ngaio).

Egg-laying and Larva.

Ova laid singly in small pockets beneath lower cuticle of leaf. Usually three or four pockets, all containing ova, very close together.

Full-grown larva 4 mm., long, pale greenish-yellow, shiny, darker posteriorly; mandibular sclerite has only two teeth in all three instars. Length of pharyngeal skeleton, exclusive of mandibular sclerite—first instar, 0·13 mm.; second instar, 0·24 mm.; third instar, 0·35 mm. Length of mandibular sclerite—first instar, 0·035 mm.; second instar, 0·06 mm.; third instar, 0·09 mm. First moult occurs at a point about 1 cm. from start of mine, second usually within blotch.

The Mine. (Plate 39, fig. 4.)

Disturbing influences being absent, the mine of this fly is a narrow gallery throughout, tortuous in direction, but rarely vermiform—that is, looping closely back and forth upon itself. It is a usual and marked characteristic for several closely adjacent egg-pockets to contain ova of same age, undoubtedly laid by same parent; these hatch together, and larvae tunnel along under upper cuticle of leaf; galleries extremely narrow, black with contained frass, their directions slightly tortuous but practically parallel with one another. At the end of 1 cm. first moult takes place, and galleries then begin to develop short blind branches; these from the several mines meet and intermingle, and so is formed a large irregular blotch. The larvae, however, do not work in common; each strives to maintain its own gallery: the blotch is a fortuitous structure. Frass relatively plentiful, black, semi-viscid. Colour of blotch dark grey-brown in older parts, dark green where fresh, with pale margins.

Mines conspicuous objects on upper sides of leaves; blotches are from 1 sq. cm. and upwards in size. Individual galleries may average 7 cm. in length. Midrib forms no obstacle. "Herring-boning" not as heavily marked as in mines of veronica-flies. Full-grown larvae escape through small slit in upper cuticle. Margins of gallery very irregular. The dry cuticle over blotches soon becomes much wrinkled.

The Pupa. (Figs. 7, 8.)

Leaving mine, larva descends, but does not appear to enter ground. Colour of fresh pupa light yellowish-brown, but within twenty-four hours black. Dorsum evenly rounded; cephalic extremity bluntly pointed; segments narrowing from behind cephalad, not prominently rounded, sculptured with fine annular striae and very slightly hollowed anteriorly in mid-dorsal line. A single row of minute dark-coloured dots between segments. Anterior respiratory processes small, short, and close together; posterior pair large, mushroom-shaped, or prominent tubercles. Antero-lateral shoulders not developed.

Average dimensions: Length, 2·79 mm.; greatest dorso-ventral diameter, 1·17 mm.; greatest transverse diameter, 1·38 mm.

Duration of pupal stage, twenty days and upwards.

(19.) **Agromyza clianthi** n. sp. (The Clianthus-fly).

Male. Frons, palpi, genae, and proboscis yellow; antennae darker yellow, brownish above; arista black, pubescent; eyes very dark reddish-brown; occiput and ocellar triangle black; each orbit with three strong bristles; ocellar bristles weaker and shorter than the post-verticals.

Thorax dark grey upon dorsum, lateral margin in front of wing-base broadly yellow, pleural sutures yellow; four pairs of dorso-central bristles, anterior two pairs much weaker than posterior, setulae between them long and sparse, arranged in two irregular series; scutellum broadly yellow from base to apex.

Abdomen dark grey above, posterior margins of tergites slightly yellowish; lateral margins yellow.

Legs—femora yellow, brownish near costa; tibiae and tarsi dark brownish-grey.

Wings (fig. 27) pale-greyish, veins black, extreme base yellowish; halteres lemon-yellow; penultimate section of fourth vein one-sixteenth as long as ultimate, and one-ninth as long as ultimate section of fifth.

Length, 1·5 mm. Female similar to but slightly larger than male.

Type in author's collection; bred from mines obtained in Virginia Reserve, Wanganui.

Distribution.

First discovered in Virginia Reserve, Wanganui, in September, 1915, and found there commonly every year since. Has also been found at Heretaunga (Trentham) and Dunedin. Imagines appear to be most common in September, November, and following summer months. Probably three or four generations.

Food-plant.

Clianthus puniceus (parrotsbill, kaka-beak).

Egg-laying and Larva.

Ova laid singly in small pockets constructed beneath under-cuticle of leaf, and usually close to outer margin.

Full-grown larva yellow in colour, shiny, 2 mm. in length. Duration of larval stage probably not longer than two to three weeks. Three stadia. Mandibular sclerite possessing only two teeth.

The Mine. (Plate 38, fig. 2.)

A small simple expanding gallery on upper side of leaf throughout. Width increases gradually from about 0·25 mm. to about 2 mm.; average length, 3–4 cm. Mine as a rule follows margin of leaf more or less closely, being directed first towards apex, and, crossing midrib here, passes on down opposite half of leaf, terminating, after a slightly serpentine course, in vicinity of base. Margins irregular in outline, but blind branches never present. Colour light-green when fresh, white later. Little or no indication of mine on underside of leaf, excepting, of course, the egg-pockets, the majority of which never contain ova. Frass deposited in minute semi-viscid masses, dark-green when fresh, but soon becoming black and clearly showing through transparent cuticle covering mine; deposition of frass very characteristic, occupying two almost parallel interrupted lines of granules increasing in size as mine expands, and occupying central part of gallery; this causes mine to assume a darker tone in centre, with pale margins. Larvae emerge from mine when fully grown, cutting a small semicircular slit through floor of gallery. Two or more larvae may be found mining in same leaf, though as a rule there is but one larva to a leaf.

The Pupa. (Figs. 5, 6.)

Larva pupates amongst vegetation near ground. Pupa differs but little in main features from those already described. Colour pale amber-brown; segments moderately rounded, smooth and shining; on lateral intersegmental regions are a number of microscopic spines; dorsally segments are slightly produced caudad in mid-line.

Average dimensions: Length, 1·93 mm.; greatest ventro-dorsal diameter, 0·86 mm.; greatest transverse diameter, 1 mm.

Duration of pupal existence usually averages twenty to thirty days. Dehiscence occurs as in previous species.

Fig. 1.—Portion of a veronica-leaf heavily mined by *A. flavocentralis*. Note "herring-boning" within the gallery, the line of frass, and old egg-pockets scattered over the leaf. × about 4. (Camera-lucida sketch.)

Fig. 2.—Mine of *A. clianthi* in a leaf of *Clianthus puniceus*. Note characteristic double line of frass. × about 4. (Camera-lucida sketch.)

Fig. 3.—Mine of *A. umbrina* in veronica-leaf; seen by transmitted light. Note the heavy "herring-boning." The pale area at the start of the mine is caused by the preliminary mining on the opposite side of the leaf. × about 4. (Camera-lucida sketch.)

Fig. 4.—A blotch mine of *A. umbrina* cut across transversely, showing in the interior the pupa attached by its caudal thread to the floor of the mine. Greatly enlarged. (Photo.)

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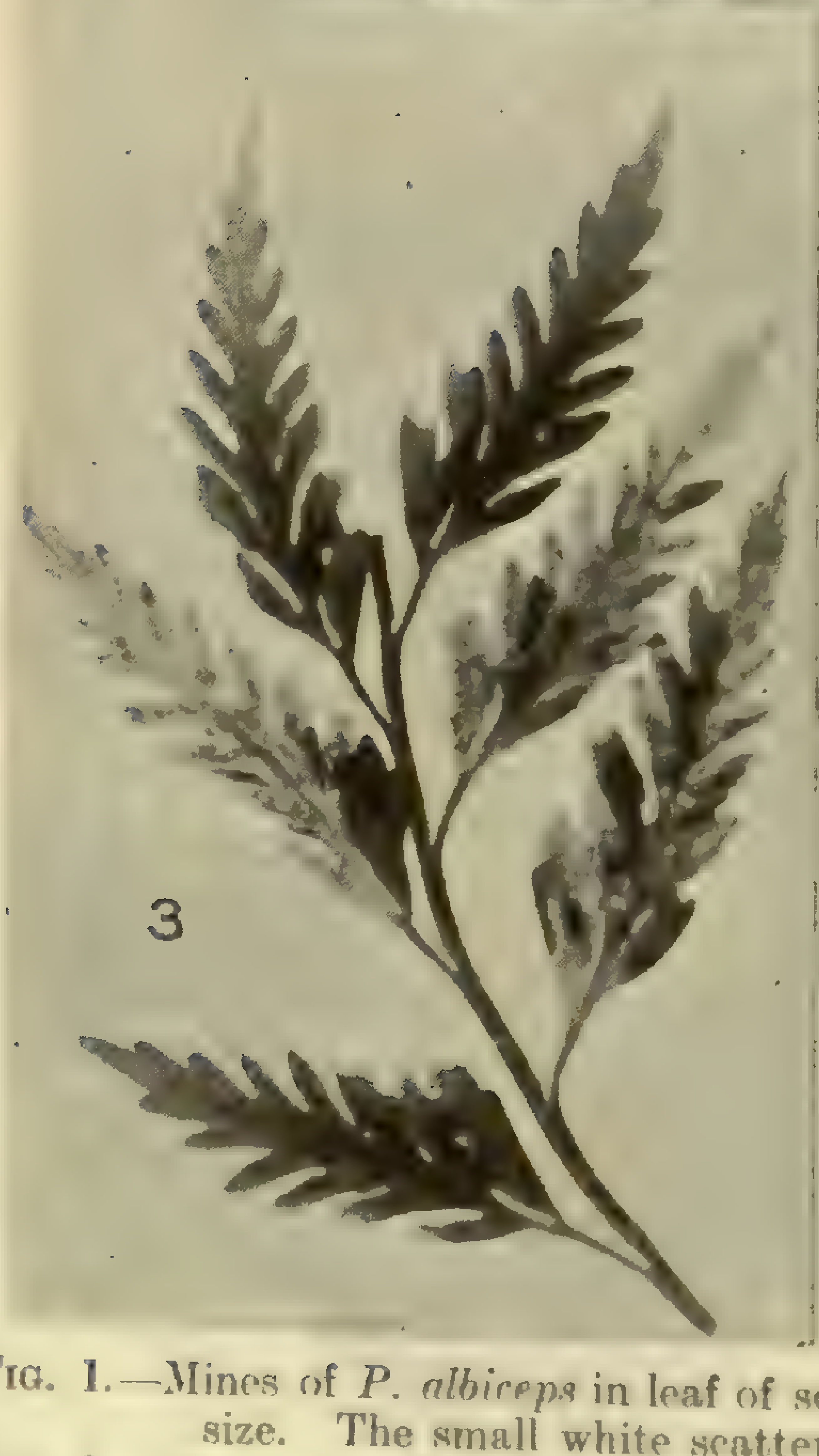
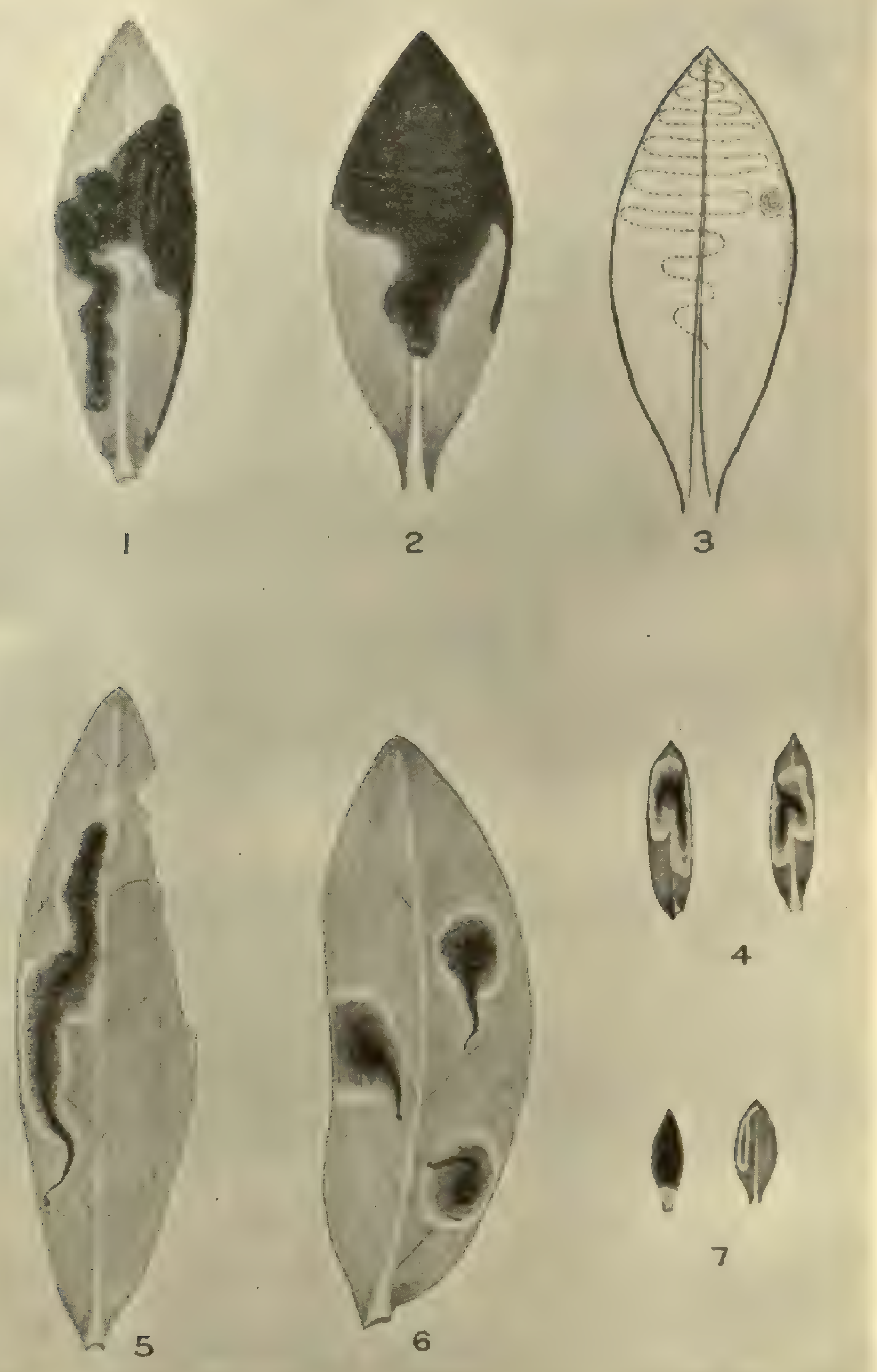


FIG. 1.—Mines of *P. albiceps* in leaf of sow-thistle. Photo by direct contact. Natural size. The small white scattered spots are "egg-pockets."

FIG. 2.—Mine of *A. flavopleura* var. *casta* in leaf of *Asplenium lucidum*. Natural size. Photo by direct contact.

FIG. 3.—Mines of *A. flavopleura* in *Asplenium flaccidum*. Photo by direct contact. Natural size.

FIG. 4.—Mines of *A. citreifemorata* in ngaio-leaves. About natural size.



FIGS. 1, 2.—Mine of *A. flavocentralis* in veronica-leaf.
FIG. 3.—Sketch showing track taken by larva, fig. 2.
FIG. 4.—Mines of *A. umbrosa* in veronica-leaf.
FIG. 5.—Mine of *A. flavocentralis* in veronica-leaf.
FIG. 6.—Mines of *A. umbrina* in veronica-leaf.
FIG. 7.—Mine of *A. umbrinella* in leaf of *Veronica Colensoi*, showing upper and under surfaces.
(Camera-lucida drawings. All natural size.)

Figs. 1, 2.—Mines of *P. clematadi* in leaves of *Clematis indivisa*.
Figs. 3, 4, 5.—Mines of *A. flavolateralis* in leaves of whiteywood (*Melicytus ramiflorus*).
(Camera-lucida sketches. Natural size.)

(20.) **Agromyza flavopleura** n. sp. (The Fern-fly).

The Imago.

Male: Frons, antennae, palpi, proboscis, and genae lemon-yellow; ocellar triangle and occiput black; arista pubescent, black; eyes dark red; each orbit with three bristles and a number of long fine hairs; ocellar bristles weaker than the post-verticals.

Thorax black on dorsum, shining; pleura almost entirely lemon-yellow, two blackish spots, one on sternopleura and a smaller one above hind coxae; scutellum black, except at antero-lateral margins, where it is yellowish, as in adjoining part of thorax; anterior two pairs of dorso-centrals but little shorter than the two posterior pairs; about four irregular series of rather long setulae between dorso-centrals.

Abdomen infuscated except at extreme base, and narrowly at extreme apex of each tergite; under-surface yellowish.

Legs—coxae and femora lemon-yellow, tibiae and tarsi grey-brownish.

Wings (fig. 28) clear, veins dark fuscous, bases yellow; penultimate section of fifth vein over three-fourths as long as ultimate, last section of fourth vein about five times as long as penultimate; halteres yellow.

Length, 3 mm. Female similar to male.

Type in author's collection; reared from mines obtained in Botanical Gardens, Dunedin.

Distribution.

First found at Wellington, in the Botanical Gardens, 19th June, 1919 (fairly plentiful), and has been taken in same locality from time to time since. Found also at Wanganui (scarce) and at Dunedin. Imagines best procured by rearing from mines, and will be found emerging throughout summer months till April.

Food-plants.

Polypodium australe, P. Billardieri, Lomaria filiformis, Asplenium flaccidum.

Egg-laying and Larva.

Ova laid singly in minute pockets constructed beneath under-cuticle of leaves; there appears to be no especially selected part.

Full-grown larva when fully extended 6 mm. in length, just prior to pupating 3·5–4 mm., cylindrical, slightly expanded cephalad in region of third segment; light yellow, shining; mandibular sclerite in each of the three instars with but two teeth; anterior respiratory processes long and slender, about one and a half times the length of the mandibular sclerite. Length of pharyngeal skeleton, exclusive of mandibular sclerite—first instar, 0·19 mm.; second instar, 0·29 mm.; third instar, 0·43 mm. Length of mandibular sclerite—first instar, 0·03 mm.; second instar, 0·07 mm.; third instar, 0·13 mm. Durations of stadia not known.

The Mine. (Plate 39, fig. 3.)

Under favourable conditions, a long, narrow, tortuous gallery. Margins fairly regular. Owing often to narrow fronds, gallery is so much involved as to become in many cases, and especially in *A. flaccidum*, a blotch covering almost the entire leaflet. Constructed closer against lower cuticle than upper, but just as conspicuous on one side as other. Colour pale green, becoming white, generally slightly discoloured brownish in region of the pupa and at tips of leaflets. Frass dark green to black, very scanty,

irregularly scattered throughout mine, can be easily seen from exterior, and mostly deposited against roof of mine. Gallery may extend into stalks of fronds. In longer and larger leaves of *L. filiformis* gallery is seen at its best, attaining an average length of 12–18 cm.. Frequently several larvae mine in a single leaf.

The Pupa. (Figs. 1, 2.)

Larva pupates within mine in terminal portion. Pupa firmly cemented to roof of mine (occasionally the floor), and dorsal halves of first three and a half segments become flattened to form a definite head-plate, exposed to exterior of mine, a small flap of cuticle being uplifted here. Pupa is flattened dorso-ventrally; greatest diameter about sixth segment; rounded anteriorly; bluntly pointed caudal extremity interrupted by the two tubercles bearing posterior spiracles. Segments barely rounded, of almost equal length, sculptured with remarkably fine annular striae, shiny; a single line of small dark spots between each segment. Hinder segments slightly produced anteriorly in mid-dorsal line; there is, of course, no antero-lateral shoulder. Head-plate bears near extremity the two anterior respiratory processes; these are dark brown, elevated, directed upwards and laterally, each on a distinct tubercle, and they are as far apart as posterior pair; these latter are shorter, directed backwards and downwards, and not expanded at tips, dark brown in colour at tips. Colour of pupa very pale amber, yellowish posteriorly. On dorsum a more or less well-marked median stripe of darker brown, commencing about the next to last segment and gradually expanding cephalad; head-plate light brown with a central stripe of ground-colour.

Average dimensions: Length, 3·24 mm.; dorso-ventral diameter, 0·86 mm.; transverse diameter, 1·21 mm.; length of head-plate, 1 mm.

Average duration of pupal period, twenty-five days. On dehiscence dorsal head-plate, with its respiratory processes, is lifted up, allowing fly to escape; also a slight amount of splitting ventrally around transverse suture.

(21.) Agromyza flavopleura var. casta n. var.

The Imago.

Male differs from preceding species in having no blackish spots on pleura. Length, 3 mm. Female similar to male.

Type in author's collection; reared from mines obtained in Botanical Gardens, Wellington.

Distribution.

First discovered in Wellington Botanical Gardens, 19th June, 1916. Has also been found at Karori, Day's Day, and Petone, but so far not recorded outside environs of Wellington. Imagines emerge September to January, probably throughout summer. Uncommon.

Food-plant.

Asplenium lucidum.

Egg-laying and Larva.

Apparently similar in all respects to *A. flavopleura.*

The Mine. (Plate 39, fig. 2, and text-figs. 31–34.)

Mine an extremely long narrow conspicuous white gallery, its margins more or less even, blind branches frequent. General course of mine more or less influenced by ribs of leaf. Galleries, usually two or more in a leaf, extend aimlessly over surface, rarely following outer margin of leaf, and cross each other in all directions, rarely forming a blotch in so doing. Average width of gallery, 1·5–2 mm. Midrib appears to exercise but little influence, cuticle being frequently lifted from it in course of the mine. "Herring-boning" well but not heavily marked. Frass practically negligible, occupying thin broken line along one or other side of gallery. Entire mine close under upper cuticle and little evidence of it on underside. Total length, 15–30 cm. or more.

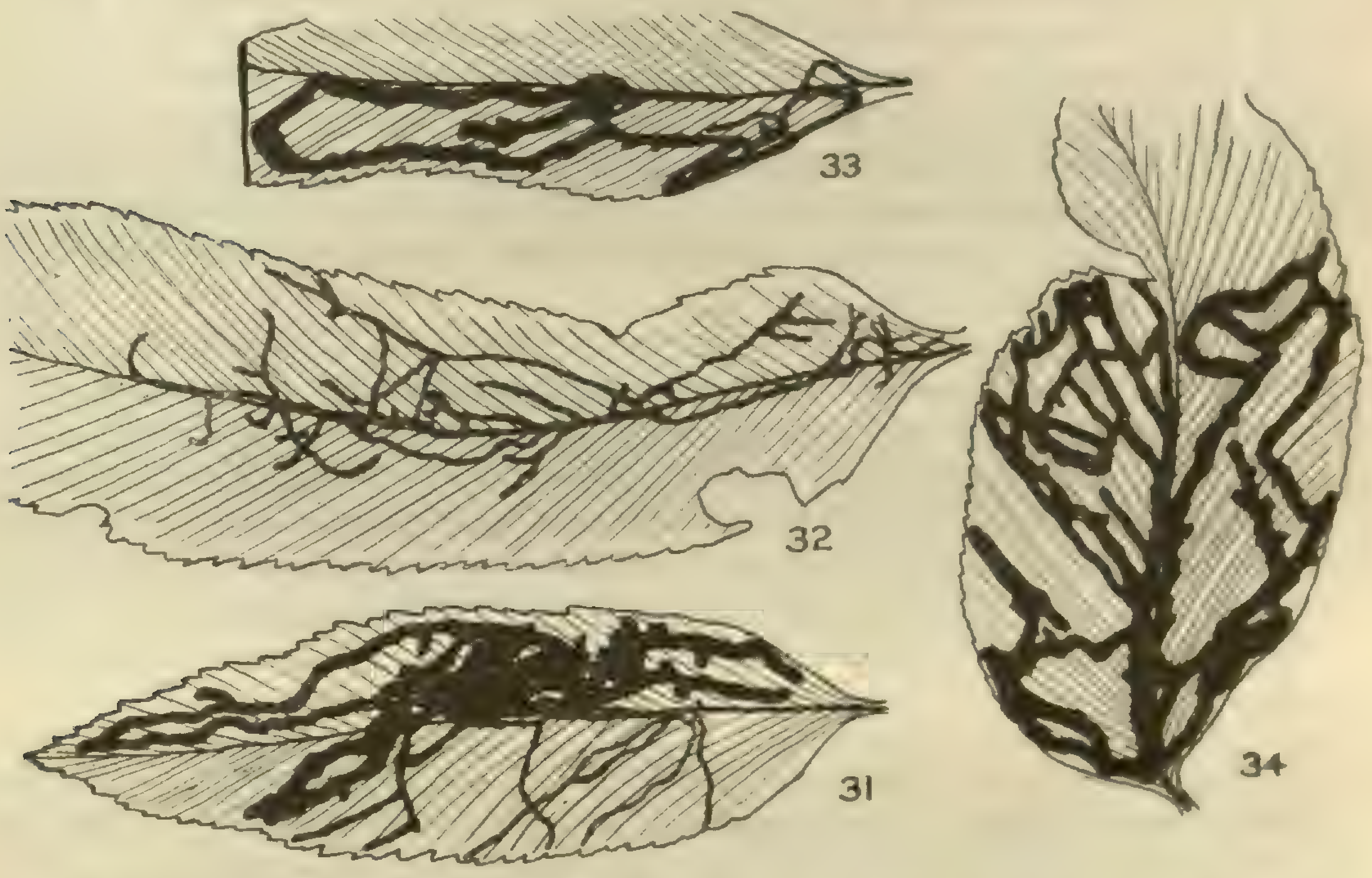


FIG. 31.—Three complete mines of *A. flavopleura* var. *casta* in a leaf of *A. lucidum.*
FIG. 32.—The work of four young larvae.
FIG. 33.—A single mine, complete.
FIG. 34.—The result of the mining operations of three larvae.
(All tracings from actual specimens; about one-half natural size.)

The Pupa.

Similar to that of *A. flavopleura*, already described. The following differences occur: Colour, excepting head-plate and spiracles, white; head-plate and anterior respiratory processes entirely dark rich brown, almost black; tips of the tubercles bearing posterior respiratory processes dark brown, the processes themselves white: a very pale yellowish line between each segment; dorsal streak brown and confined to segment immediately behind head-plate, it is expanded and very dark anteriorly. Anterior respiratory processes as far apart as, or farther than, posterior pair, longer and more slender, slightly expanded at their tips.

Average dimensions: Length, 3·38 mm.; greatest ventro-dorsal diameter, 0·68 mm.; greatest transverse diameter, 1·29 mm.; length of head-plate, 0·68 mm.

Dehiscence exactly as in *A. flavopleura.*

(22.) **Phytomyza clematadi** n. sp. (The Clematis-fly).

The Imago.

Female. Frons yellow, paler above; ocellar triangle black, ocelli brown; eyes dark red; distal joint of antenna black above, brownish beneath; arista pubescent, black; first two joints of antenna yellow, pedicel obscurely blackish above; proboscis and genae pale lemon-yellow; palpi dark brown, somewhat circular; occiput black; each orbit with four bristles, the lowermost one very weak; between the row of orbital bristles and the eye is a single series of small hairs not extending below third orbital bristle; ocellar and post-vertical bristles strong, the latter almost as strong as inner and outer verticals.

Thorax—dorsum dark greyish-brown, very faint indications of three darker narrow antero-posterior lines; four pairs of strong dorso-central bristles with two or three irregular series of setulae between the two anterior pairs; scutellum dark greyish-brown, bearing four strong bristles; a very narrow lateral line of pale green in front of base of wing; pleural sutures narrowly and obscurely green.

Abdomen dark grey above and below, pale green on sides; narrow bars of pale green between segments.

Legs—first coxae yellowish except for a small area of brown at base; first femora yellowish with obscure brownish darkening towards tibiae; second and third coxae and femora obscurely brownish-yellow; all femero-tibial joints yellow; tibiae and tarsi dark grey, joints yellowish.

Wings (fig. 30) pale-greyish, veins black; bases of wings yellowish; knobs of halteres pale yellow, stems brownish.

Length, 3 mm. Male similar to female, but slightly smaller.

Type in author's collection; reared from mines obtained in bush at Opoho, Dunedin.

Distribution.

Discovered first at Ravensbourne (Dunedin), 12th October, 1919, by Mr. W. G. Howes; since then it has been found to be plentiful throughout the Dunedin district. Has also been found at Heretaunga (Trentham).

Food-plant.

Clematis indivisa (puawananga, pikiarero).

Egg-laying and Larva.

Eggs laid singly in pockets constructed almost invariably beneath lower cuticle of leaves; no apparent preference for any particular part. Pockets not so elaborately made as in *P. albiceps*, one diagonal thrust of ovipositor into leaf-tissues being apparently all that is necessary. Here also a large number of pockets are constructed, but no eggs deposited therein. Old pockets become very conspicuous on the leaves, both on upper and under surfaces.

Full-grown larva pale green; length, 4 mm. Particulars of stadia not known.

The Mine. (Plate 41, figs. 1, 2.)

A fairly long narrow gallery, averaging 1·5–2 mm. in width. As a rule, all except the final 2 cm. or so lies close beneath upper cuticle of leaf.

Direction of mine tortuous, and in small leaves markedly vermiform; little tendency to formation of branches; margins fairly even and almost parallel. Colour conspicuously white except when covering cuticle is quite fresh, then pale green. Neither veins nor midrib appear to be any barrier to larva at any stage of its existence. Margin of leaf rarely followed closely except for very short distances. At terminal part gallery widens slightly, and within this area larva pupates. Frass scanty, deposited in minute black semi-fluid spots in a single narrow line towards one side of gallery. Very little evidence of mine on underside of leaf. Rarely more than one larva to a leaf. Not only are leaves nearest ground attacked, but also those 15 ft. to 20 ft. up. Average length of mine, about 15 cm.

The Pupa. (Figs. 15, 16.)

Pupa well cemented to floor and roof of mine. The two anterior respiratory processes are thrust through cuticle of leaf to exterior. There appears to be no decided preference for one side of the leaf or the other. Pupa flattened dorso-ventrally, and as viewed from above somewhat ovoid in shape; segments barely rounded, slightly roughened, and shiny, a slight shallow transverse furrow in centre of dorsum of each segment both in front and behind; a single row of minute spots and several series of microscopic spines in intersegmental regions. *Ventral* halves of first three and a half segments slightly flattened to form a "head-plate," and in consequence anterior end of pupa with anterior respiratory processes is directed ventrad; respiratory processes are not here connected with "head-plate," as in *A. flavopleura*; they are fairly long and slender, knobbed, fairly close together, and arise from a distinct tubercle. Posterior respiratory processes stouter, about half the length of the anterior, farther apart, and barely expanded at their tips. Colour of pupa dark brown (dark amber in empty puparia), with a darker mid-ventral stripe which widens cephalad and is almost black at anterior end. Anterior respiratory processes black, and posterior ones very dark brown at their tips; head-plate dark brown with an obscurely darker central band. Anal aperture slightly sunken.

Average dimensions: Length, 2·7 mm.; greatest ventro-dorsal diameter, 0·76 mm.; greatest transverse diameter, 1 mm.; length of ventral head-plate, 0·63 mm.

Average duration of pupal existence under normal conditions, thirty days.

On dehiscence the ventral head-plate breaks through cuticle of leaf and allows fly to emerge; also a slight splitting dorsally around transverse suture. Unlike *A. flavopleura*, where dorsum of pupa is outermost—that is to say, next cuticle through which the anterior respiratory processes are extruded—in both *P. clematadi* and *P. albiceps* it is the ventral surface that is outermost.

(23.) **Phytomyza albiceps** Mg. (The Thistle-fly).

Phytomyza albiceps Mg.: Miller and Watt, *Trans. N.Z. Inst.*, vol. 47, p. 279, 1915.

The commonest and most widely spread leaf-mining fly in New Zealand, its white galleries showing conspicuously in the leaves of the common sow-thistle. It has been identified at the Imperial Bureau of Entomology as *P. albiceps*, and, as mentioned previously, it is quite possible that it is

the same fly as has been quoted from time to time by T. W. Kirk in the *N.Z. Journal of Agriculture.* Owing to several inaccuracies in the former paper, it has been found necessary to review it and bring it into line with the present series. The following account entirely supersedes the earlier article.

P. albiceps is attacked by several small hymenopterous parasites, fully 90 per cent. of the larvae perishing from this cause. All the parasites that have emerged in the breeding-jars from this and other leaf-mining hosts are being carefully preserved, with notes on their life-histories, and will be dealt with in a separate paper.

The Imago.

Female. Frons and genae yellowish ; ocellar triangle and occiput dark grey ; antennae entirely black ; arista pubescent ; eyes reddish-brown, widely dichoptic ; ocelli dark orange ; palpi black ; proboscis lemon-yellow ; each orbit with three strong bristles, and between these and the eye a single series of fine hairs extending the whole length of the front ; ocellar and post-vertical bristles about equal, and much weaker than inner and outer verticals.

Thorax dark grey ; four pairs of dorso-centrals with rarely any setulae between them, two anterior pairs are weaker than the posterior, and any setulae that may be present are situated between the former. Scutellum dark grey, with four strong bristles.

Abdomen dorsally dark grey with narrow pale-green intersegmental lines ; sides pale green ; under-surface dark grey with green intersegmental lines.

Legs dark grey to black ; femero-tibial joints yellowish.

Wings (fig. 29) colourless, bases yellowish, veins dark grey ; halteres pale lemon-yellow.

Length, 2 mm. ; wing, 2·5 mm. Male similar to female but slightly smaller—length, 1·5 mm. ; wing, 1·75 mm.

Food-plants.

The common sow-thistle (*Sonchus asper*), also on *S. oleraceus* and *S. arvensis ;* Scotch thistle ; dandelion ; nettle ; Cape weed (*Cryptostemma calendulacea*) ; common groundsel (*Senecio vulgaris*) ; *Erechtites arguta* and *E. praenanthoides* ; dahlia ; large cultivated daisy ; and possibly also in cineraria, chrysanthemum, marguerite, *Melilotus*, Noogoora burr.

Distribution.

Apparently common throughout New Zealand ; has been found plentifully at Whakamarina, Wanganui, Wellington, Christchurch, and Dunedin.

Ovum, Egg-laying, and Larva.

Ovum cylindrical, pearly-white, glossy, ends rounded ; shell very delicate, and devoid of any kind of sculpturing. The micropylar (?) end slightly broader than its nadir.

Length, 0·32 mm. ; greatest diameter, 0·15 mm.

The female fly appears to deposit her ova on both surfaces of the leaves of the food-plant. Close observations show that the upper side is almost

invariably preferred, the majority of eggs being laid on the outer margin of the leaf. Having selected a suitable spot for oviposition, the fly lowers her ovipositor till it is at right angles to the surface of the leaf, having to stand on tip-toe for the purpose; with several downward jerks of the abdomen the ovipositor is thrust through the cuticle and pushed beneath its surface, pushing at first directly backwards and later laterally, in this way prising up the cuticle so as to form a minute semicircular pocket in the leaf. After a moment's rest the ovipositor is withdrawn, leaving a single egg within the pocket. Some little time after the cavity has been made the separated cuticle dries, and the whole becomes visible to the naked eye as a minute white spot on the leaf.

While engaged in laying, the fly is very sluggish, and can be closely observed with a magnifying-glass without taking to flight, and can even be gently transferred from one leaf to another; it is, however, extremely rapid of flight. Almost invariably on the withdrawal of the ovipositor from the leaf the fly will immediately turn and eagerly lap the exuding sap. Before continuing the process of laying, the ovipositor and body generally are subjected to a thorough cleansing; all extraneous matter is removed. The egg-laying capacity of any individual probably reaches about 200 ova. The time taken in probing a cavity and depositing the egg rarely exceeds a minute. During the proceedings the back legs are at times violently stamped upon the leaf. Occasionally leaves are found crowded with these pockets, but in such cases only a few of them will contain eggs.

Under normal conditions lava hatches on sixth day after laying of egg, and commences burrowing against upper cuticle of leaf. It passes through three stadia: the first occupies about three days, moult taking place about 1 cm. along mine; second stadium occupies about three days, moult occurring about 4 cm. along mine; third and final stadium occupies about four days, and lava pupates within mine.

Full-grown lava a minute cylindrical grub; cephalic extremity slightly broader than caudal end; colour white, inclining to pale green on account of assimilated food and transparency of skin; head is largely retractile; posterior respiratory processes minute and black, anterior pair white and longer. Average length of full-grown larva, 3 mm.; average diameter, 0·9 mm.

Pharyngeal skeleton fairly strong and black; consists of two similar halves joined cephalad of a narrow cross-bar: each half consists of a long narrow horizontal bar, broadest caudad, and joined at about junction of anterior third and posterior two-thirds of a shorter, more slender, mid-lateral process; anteriorly the mandibular sclerite (also a double process) bears on either half two strong curved teeth. Number of teeth the same in each instar. Average length of pharyngeal skeleton—first instar, 0·13 mm.; second instar, 0·21 mm.; third instar, 0·34 mm.

The Mine. (Plate 39, fig. 1.)

Mine a long narrow gallery, frequently forming an intricate pattern on leaf owing to tortuous course, it and other mines on same leaf crossing each other in grand confusion. Longer or shorter blind branches are frequent. Margins of gallery even and almost parallel. The greater length of mine, as a rule, lies close against upper cuticle, and there is little trace of it on under-surface. In cases where egg has been laid on under-surface the mine will lie close against this for a short distance at first, but sooner or later

comes to lie against upper epidermis. Occasionally, however, a mine may be found altogether on under-surface of leaf. Towards end of third stadium larva forsakes upper side of leaf for lower, and finally pupates within slightly expanded terminal part of mine, the anterior respiratory processes being thrust through lower cuticle to exterior. Pupation seldom takes place on upper side of leaf. Light appears to govern to a great extent the choice of position for pupation; in instances where leaves were placed in the dark the larvae pupated on whatever side of leaf they happened to be mining at the time, whereas in leaves kept in the light the larvae pupated on the side farthest from source of light. Colour of mine white, very conspicuous. Frass black, granular, scanty; granules deposited in a thin interrupted line along one or other side of floor of gallery. Total length of mine averages 15 20 cm., the last 12 cm. or so being constructed during third (final) stadium. Individual leaves may contain eight to ten or more larvae, but these avoid each other as far as possible.

The Pupa. (Figs. 17, 18.)

Pupa somewhat elongated; segments only moderately rounded and tending to be slightly produced caudad in mid-ventral region, each, excepting the four anterior ones, possessing ventrally two short shallow transverse furrows in central line, best marked in middle segments. Anterior end of pupa pointed, and at extreme tip bears the two short slightly knobbed anterior respiratory processes, these being placed very close together, closer than in *P. clematadi;* caudad to these processes, but not including them, ventral portion of first three and a half segments is somewhat flattened to form an ill-defined head-plate, which lifts on dehiscence; in consequence anterior end of pupa is distinctly downturned in dorsal profile, since anterior respiratory processes and head-plate are all on a level with ventral surface of pupa, this surface being outermost as pupa is situated in mine. Posterior extremity bluntly rounded; anal protuberance considerably masks posterior respiratory process when viewed ventrally; these latter are short and stout, knobbed, and relatively far apart. Anterior processes thrust through cuticle to exterior. Colour of pupa pale amber-brown dorsally, darker ventrally, with broad dark mid-ventral stripe extending whole length; anterior processes rich brown, paler at tips; posterior processes black-tipped.

Average dimensions: Length, 2·45 mm.; greatest ventro-dorsal diameter, 0·83 mm.; greatest transverse diameter, 1 mm.; length of ventral head-plate, 0·5 mm.

Duration of pupal existence under normal conditions, twelve to thirteen days. Dehiscence as in *P. clematadi.*

Agromyza australensis Mik.

A. australensis Mik., *Verh. z.-b. Wien*, xxxi, p. 202, pl. xiii, fig. 15, 1881; Hutton, *Trans. N.Z. Inst.*, vol. 33, p. 93, 1901.

"Greyish-brown; the abdomen, in some lights, luminous grey; middle and hind legs pale-tawny. (The fore legs missing.) Posterior cross-vein about twice its length from the chief cross-vein, and about one and a half times its length from the margin.

"Length, 1¾ mm.; wing, 2 mm.

"*Hab.*—Auckland Islands (Dr. Krone)."

RECAPITULATION.

—	Food-plant.	Mine.	Pupation.	Pupa.
Agromyza umbrina ..	*Veronica* (larger-leaved varieties)	Gallery, 2–4 cm., and blotch, 1·5 sq. cm. Dark	Within mine	Attached to floor of mine by a thread.
A. umbrinella ..	*Veronica Colensoi* ..	Gallery, 1 cm., and blotch, 20 sq. mm. Dark	Within mine	Ditto.
A. flavolateralis ..	Whiteywood (*Melicytus ramiflorus*)	Gallery, 9 cm. White	Outside mine	Free
A. flavocentralis ..	*Veronica* (larger-leaved varieties)	Gallery, 5–14 cm. Dark	Outside mine	Free.
A. umbrosa	*Veronica monticola*	Gallery, 2½–4 cm. Dark	Outside mine	Free.
A. citreifemorata ..	Ngaio (*Myoporum laetum*) ..	Gallery, 7 cm. (sometimes blotch). Dark.	Outside mine	Free.
A. clianthi	*Clianthus puniceus*	Gallery, 3–4 cm. White	Outside mine	Free.
A. flavopleura ..	*Polypodium, Asplenium, Lomaria*	Gallery, 13–18 cm. White ..	Within mine	Attached to roof and floor of mine; specialized dorsal head-plate. Dark dorsal stripe.
A. flavopleura var. *casta*	*Asplenium lucidum*	Gallery, 15–30 cm. White ..	Within mine	Attached to roof and floor of mine; specialized dorsal head-plate. No dorsal stripe, or confined to one segment.
Phytomyza clematadi ..	*Clematis indivisa*	Gallery, 15 cm. White	Within mine	Attached to roof and floor of mine; ventral head-plate. Ventral stripe.
P. albiceps	Thistle (see list of food-plants) ..	Gallery, 15–20 cm. White ..	Within mine	Ditto.

Art. 35.—*Notes on the Migratory Plovers of New Zealand, with Records of some Additional Species.*

By Edgar F. Stead.

[*Read before the Philosophical Institute of Canterbury, 7th September, 1921; received by Editor, 31st December, 1921; issued separately, 12th May, 1923.*]

Here in New Zealand we do not have, as in the colder climates of the Northern Hemisphere, many returning birds which herald the approach of summer, yet we have birds which come to us from the other end of the earth, and have even, in some cases, travelled more than half round the world to reach us.

Vetola lapponica baueri Naumann, 1836. Bar-tailed or Pacific godwit.

Limosa baueri Naumann, *Vög. Deutschl.*, 8, p. 429, 1836. *Limosa lapponica* subsp. *novae-zealandiae* Sharpe, *Cat. Birds Brit. Mus.*, vol. 24, p. 377, 1896. *Limosa novae-zealandiae* Buller, *Suppl. Birds N.Z.*, vol. 1, p. 181, 1905. *Limosa lapponica baueri* Mathews and Iredale, *Ibis* for April, 1913, p. 258. *Vetola lapponica baueri* Ridgway, *Bull. U.S. Nat. Mus. No. 50*, pt. 8, p. 187, 1919.

Most of our regular migrants belong to the Charadridae, or plover family, and the best-known among them is the Eastern bar-tailed godwit —the *kuaka* of the Maori. Buller, in his *Supplement to the Birds of New Zealand*, quotes from a newspaper an interesting paragraph headed "The Kuaka's Mistake," the author of which suggests that the godwits should go to the Antarctic to breed rather than to the Arctic, as the journey is shorter. This writer did not, apparently, realize that, while there are very large tracts of land near the Arctic Circle which are not snow-bound in the summer, there are practically no breeding-grounds for land-birds in the Antarctic.

On the approach of summer in the high latitudes of the Northern Hemisphere the snow recedes, uncovering rich feeding-grounds for a vast concourse of birds. Of this host, a large proportion consists of members of the plover and duck families, many species of which breed right up in the Arctic Circle and then migrate south for the winter. This migration, so far as the plovers are concerned, may be roughly classed under three heads: (1) The American birds, which migrate chiefly up and down the American Continent; (2) the European birds, which come down to Africa and India; and (3) the Asiatic, which come down through China and the Malay Archipelago to Australia and New Zealand: all three streams leaving birds in suitable localities along their routes. Most of the plovers are gregarious in the winter, and so, no doubt, odd specimens, and even small flocks, of a species which does not normally migrate to New Zealand would get entrained by a flock that did so, and come along with it. In this way, it seems to me, practically all the Asiatic migratory species of plover will sooner or later visit New Zealand, though many of them at the present time have not been recorded any farther than Australia.

When, in 1902, I got the first specimen of the Hudsonian godwit here, the late Captain Hutton wrote in an interesting manner of the various routes the bird could have followed in coming. As he then said, the bird could have come from Alaska via Siberia, the coast of China, the Malay Archipelago, and Australia; but that, as it had not been recorded in Australia, it was strange that it should have been got in New Zealand. He points out the disadvantage that the "San Francisco route" has of one stretch of sea of over two thousand miles. Since then three more specimens of this godwit have been obtained here, though it is, so far as I can find out, still unrecorded from Australia. Another bird, the pectoral sandpiper, which has normally the same range as the Hudsonian godwit—namely, from Arctic America to Patagonia—has lately been fairly common here, though it also is unrecorded from Australia. Both of these species might, of course, have come to us from Patagonia through the Antarctic, but this I regard as extremely improbable. I, personally, have little doubt that they came via Siberia and the eastern coast of China. We know very little at present of the course the plovers follow in the immediate vicinity of New Zealand. I have a record of golden plovers visiting a steamer between Sydney and Wellington, which would indicate that these birds had travelled well down the coast of Australia before crossing to New Zealand. On the other hand, the occurrence of the Hudsonian godwit, pectoral sandpiper, and little stint in New Zealand (see below), though they are not reported from Australia, suggests that perhaps these birds come via the Solomon Islands and New Caledonia. By whatever course they came, I think we may take it for granted that these stragglers were accompanying some of our regular migrants, following their regular route.

Canutus canutus (Linnaeus), 1758. Knot.

Tringa canutus Linnaeus, *Syst. Nat.*, ed. 10, p. 150, 1758; Sharpe, *Cat. Birds Brit. Mus.*, vol. 24, p. 593, 1896; Buller, *Suppl. Birds N.Z.*, vol. 1, p. 187, 1905. *Canutus canutus* Mathews and Iredale, *Ibis* for April, 1913, p. 261; Ridgway, *Bull. U.S. Nat. Mus. No. 50*, pt. 8, p. 231, 1919.

In January of this year I stayed two days at the lighthouse on Farewell Spit. The bay inside the spit, where the tide recedes for a distance of nearly nine miles, is one of the great feeding-grounds for the migratory plover in New Zealand, and thousands of these birds were there at the time of my visit. The great majority were bar-tailed godwits and knots, but there was also quite a number of Eastern golden plover and turnstones. Even at that early date a few knot were beginning to moult into their summer plumage, but I saw no instance of this among the godwits. When the birds first arrive here they are very thin, and the ends of the wing-primaries are much worn. After they have moulted, however, they fatten rapidly, and by April are balls of fat. There can be no doubt that they use up this fat on the journey to their northern nesting-grounds. It is a curious thing that, though numbers of godwit winter every year in New Zealand, I know of no instance of a knot's having done so; also, I have never seen a godwit here in the winter in its summer plumage, so presumably only those birds stay which have no inclination to nest that year.

Pluvialis dominicus fulvus (Gmelin), 1789. Pacific golden plover.

Chadrius dominicus P. L. S. Müll, *Natursyst.*, Suppl., p. 116, 1776. *Charadrius fulvus* Gmelin, *Syst. Nat.*, p. 687, 1789. *Chadrius dominicus* Sharpe, *Cat. Birds Brit. Mus.*, vol. 24, p. 195, 1896; Buller, *Suppl. Birds N.Z.*, vol. 1, p. 174. *Pluvialis dominicus fulvus* Mathews and Iredale, *Ibis* for April, 1913, p. 252; Ridgway, *Bull. U.S. Nat. Mus. No. 50*, pt. 8, p. 88, 1919.

The golden plover, which is a common annual migrant, does not pack into dense flocks as do the godwit and the knot, but is usually met with in rather thinly distributed companies. I have seen many hundreds of them at different times, but not more than a total of half a dozen showing any sign of the black breeding-plumage on the breast. In the third week of October, 1907, I was crossing from Sydney to Wellington, when we encountered a terrific southerly gale. During it, two golden plover came on board and took up their quarters on some cases of oranges on the after boat-deck. They stayed on board for two days, being protected from molestation by a sympathetic chief officer, and then left us. This is an interesting record, as showing how far south these birds sometimes come before crossing from Australia to New Zealand.

I will now give notes on some of the less-frequent visitors.

Mesoscolopax minutus (Gould), 1840. Little whimbrel.

Numenius minutus Gould, *Proc. Zool. Soc. Lond.*, 1840, p. 176. *Mesoscolopax minutus* Sharpe, *Cat. Birds Brit. Mus.*, vol. 24, p. 371, 1896; Buller, *Suppl. Birds N.Z.*, vol. 1, p. 181, 1905; Mathews and Iredale, *Ibis* for April, 1913, p. 257; Ridgway, *Bull. U.S. Nat. Mus. No. 50*, pt. 8, p. 411, 1919.

Records.—(1.) Lake Ellesmere (June, 1900): Canterbury Museum. (2.) Lake Ellesmere (5th March, 1921): Canterbury Museum.

This bird, of which there is only one previous record in New Zealand (in 1900), has again been obtained. A specimen was shot at Lake Ellesmere by Mr. L. A. Shand on the 5th March, 1921, and presented to the Canterbury Museum. It is very like a golden plover in its winter plumage, and, excepting for its larger size and its longer and curved bill, might easily be mistaken for that bird at a distance. Both the specimens obtained are in full winter plumage.

Vetola haemastica (Linnaeus), 1758. Hudsonian godwit, or American black-tailed godwit.

Scolopax haemastica Linnaeus, *Syst. Nat.*, 10th ed., pl 147, 1758. *Limosa hudsonica* Sharpe, *Cat. Birds Brit. Mus.*, vol. 24, p. 388, 1896; Buller, *Suppl. Birds N.Z.*, vol. 1, p. 185, 1905. *Limosa limosa haemastica* Mathews and Iredale, *Ibis* for April, 1913, p. 258. *Vetola haemastica* Ridgway, *Bull. U.S. Nat. Mus. No. 50*, pt. 8, p. 191, 1919.

Records for New Zealand.—(1.) British Museum. (2.) Canterbury Museum. (3.) Collection Edgar F. Stead. (4.) Canterbury Museum.

The first record of this bird in New Zealand was one which I shot near the mouth of the Selwyn in 1902. I did not see another until 1917, but in that year, at Lake Ellesmere, I saw a single specimen on two occasions.

On the 1st January, 1918, I again saw one near the same spot, and secured it, giving it to the Canterbury Museum. It was in full winter plumage, having none of the rusty breast-feathers which characterize the summer plumage. In February, 1919, I got another specimen, and on the 5th March, 1921, Mr. J. Fuller got one at Lake Ellesmere, giving it to the Canterbury Museum. The one first recorded (1902), which was sent by Lord Ranfurly to the British Museum, was changing into its summer plumage, but the other three are in their winter plumage.

Pisobia ruficollis (Pallas), 1776. Red-necked sandpiper.

> *Trynga ruficollis* Pallas, *Reis. Russ. Reichs*, 3, p. 700, 1776. *Limonites ruficollis* Sharpe, *Cat. Birds Brit. Mus.*, vol. 24, p. 545, 1896. Buller, *Suppl. Birds N.Z.*, vol. 1, p. 186, 1905. *Pisobia minuta ruficollis* Mathews and Iredale, *Ibis* for April, 1913, p. 260. *Pisobia ruficollis* Ridgway, *Bull. U.S. Nat. Mus. No. 50*, pt. 8, p. 290, 1919.

Records.—(1.) Edgar F. Stead (January, 1902): British Museum. (2.) Edgar F. Stead (22nd July, 1902): Canterbury Museum.

In the large suborder of the Limicolae there are many cases of two or more species which, while very different from one another in their summer plumage, are in their winter plumage very much alike. The little stint and the red-necked sandpiper form such a pair. Of almost the same size, and with very similar colouring in winter, they are yet readily separable in summer. It is therefore the more satisfactory that the one specimen of the red-necked sandpiper which we have in the Canterbury Museum is in nearly full summer plumage, so that there can be no doubt whatever of its identification. This bird I shot on the 22nd July, 1902, when it was in a large flock of banded dottrel. Earlier in the same year I had shot another bird for Lord Ranfurly, which was, I think, either this species or a little stint. Lord Ranfurly sent the specimen to the British Museum, and Mathews and Iredale, in their "Reference List of the Birds of New Zealand," refer to it as having been "named by Grant as *Tringa subarquata*, who noted that it had been first identified by Captain Hutton as a pectoral sandpiper (*Heteropygia acuminata*), and subsequently referred by him to the red-throated stint (*Limonites ruficollis*). In view of such diverse attempts at nomination, this record requires reinvestigation." It is curious that, as the specimen was readily accessible to them, they did not reinvestigate for themselves.

The specimen we have in the Canterbury Museum is well forward in its breeding-plumage, although it was shot in July; and I thought at the time, and still think, that this bird would have nested here.

Pisobia minuta (Leisler). Little stint.

> *Tringa minuta* Leisler, *Nachtr. Bechst. Naturg. Deutschl.*, 1, p. 74, 1812. *Limonites minuta* Sharpe, *Cat. Birds Brit. Mus.*, vol. 24, p. 538, 1896. *Pisobia minuta* Ridgway, *Bull. U.S. Nat. Mus. No. 50*, pt. 8, p. 268, 1919.

Records.—(1.) Taieri Flat, Otago (1902): Smyth collection, Dunedin (now E. J. Haynes, Christchurch). (2) and (3). Edgar F. Stead: Canterbury Museum.

On the 8th February, 1910, I got at Lake Ellesmere a specimen of the little stint, which I presented to the Canterbury Museum, where it was

mounted and labelled as the first record for New Zealand. Subsequently, however, a specimen labelled "Taieri Flat, 1902," was found in the Smyth collection, from Dunedin. This specimen is now in the possession of Mr. Haynes, taxidermist to the Canterbury Museum. Since then I have got five more specimens, of which I kept two in my collection and gave three to the Canterbury Museum. All the birds are in their winter plumage.

"It breeds in great numbers," says Seebohm in his *Eggs of British Birds*, "though very locally, on the Siberian tundra from Kolgneo Island and the North Cape eastward to the Taimur Peninsula . . . where it nests in July." In the winter it migrates southward to Africa and southern Asia, India, and Ceylon. This is another of those birds which come to New Zealand, almost certainly via the Malay Archipelago, which have not yet been recorded from Australia.

Calidris alba (Pallas), 1764. Sanderling.

Trynga (*alba*) Pallas, *Vroeg's Cat.*, p. 32, 1764 (Ridgway). *Tringa arenaria* Linn., *Syst. Nat.*, 12th ed., 1766. *Calidris arenaria* Sharpe, *Cat. Birds Brit. Mus.*, vol. 24, p. 526. *Calidris alba* Ridgway, *Bull. U.S. Nat. Mus. No. 50*, pt. 8, p. 308, 1919.

Record.—Edgar F. Stead (1st January, 1917): Canterbury Museum.

On the 7th January, 1917, I was at Lake Ellesmere and saw a strange bird, which I followed and finally secured. It proved to be a sanderling—the first record for New Zealand. I gave the bird to the Canterbury Museum, where it is now mounted. It is in full winter plumage, and, being so, is very like our wry-billed plover both in size and colouring. A very close examination with a good pair of field-glasses would be necessary to detect the difference between a sanderling and a wrybill in the open, if both birds were in their winter or their immature plumage. The sanderling is to be found nesting in the high north, all around the Pole, wandering in the winter southward to Africa, India, Burma, Australia and South America. It is known to nest in Grinnell Land (lat. 82° 33′), Greenland, the barren lands of North America, Alaska, the Taimur Peninsula, the delta of the Yenisei, Novaya Zemlya, and Iceland.

Pisobia acuminata (Horsfield), 1821. Sharp-tailed sandpiper.

Totanus acuminatus Horsfield, *Trans. Linn. Soc.*, vol. 13, p. 192, 1821 (Java). *Heteropygia acuminata* Sharpe, *Cat. Birds Brit. Mus.*, vol. 24, p. 566, 1896; Buller, *Suppl. Birds N.Z.*, vol. 1, p. 187, 1905. *Pisobia maculata acuminata* •Mathews, *Ibis* for April, 1913, p. 260. *Pisobia acuminata* Ridgway, *Bull. U.S. Nat. Mus. No. 50*, pt. 8, p. 276, 1919.

Buller (*Suppl.*, vol. 1, p. 187) refers to the marsh or sharp-tailed sandpiper as being very numerous in the Bay of Plenty. I feel sure that it is not so in Canterbury, for up to the present I have secured only one specimen, which is now in the Canterbury Museum.

Pisobia maculata (Vieillot) 1819. Pectoral sandpiper.

Tringa maculata Vieillot, *Nouv. Dict. d'Hist. Nat.*, 34, p. 465, 1819. *Heteropygia maculata* Sharpe, *Cat. Birds Brit. Mus.*, vol. 24, p. 562, 1896. *Pisobia maculata* Ridgway, *Bull. U.S. Nat. Mus. No. 50*, pt. 8, p. 269, 1919.

Records.—(1.) Lake Ellesmere (February, 1909): Edgar F. Stead. (2), (3), (4). Lake Ellesmere: Edgar F. Stead. (5.) (Immature specimen) Lake Ellesmere (5th March, 1920): Edgar F. Stead—Canterbury Museum.

In 1903 I shot a sandpiper at Lake Ellesmere, and put it in my collection as *Heteropygia acuminata*, and it was not until a few days ago, when I was going through some of my birds with Mr. Archey, that we discovered the bird was *Pisobia maculata*. This is the first specimen of which we have any record for New Zealand. Since then I have secured several more specimens, one of which is mounted in the Canterbury Museum, and three of which I have in my own collection. All of these birds are in their winter plumage.

There is not a great deal of difference between the marsh and pectoral sandpipers, and what there is would be almost impossible of detection in the field.

The pectoral sandpiper breeds in Arctic America and migrates south through the American continent in the winter even so far as Patagonia and the Falkland Islands. It also occurs in eastern Asia, and it is doubtless from there that these birds have come to New Zealand, joining up with the flocks of knots and godwits.

Erolia ferruginea (Brunnich), 1764. Curlew sandpiper.

Tringa ferruginea Brunnich, *Ornith. Boreal.*, p. 53, 1764. *Ancylochilus subarquatus* Sharpe, *Cat. Birds Brit. Mus.*, vol. 24, p. 586; Buller, *Suppl. Birds N.Z.*, vol. 1, p. 187, 1905. *Erolia ferruginea* Mathews and Iredale, *Ibis* for April, 1913, p. 259; Ridgway, *Bull. U.S. Nat. Mus. No. 50*, pt. 8, p. 250, 1919.

The curlew sandpiper may, I consider, be put down as one of our regular migrants. Two specimens which I shot on Lake Ellesmere on the 5th April, 1903, were the first of this species to be recorded for New Zealand, but since then I have seen it on many occasions and have secured a number of specimens. It is usually to be found associating with the banded dottrel. On one occasion I saw between twenty and thirty curlew sandpipers, which were in a large company of dottrel. When disturbed both species rose and flew around together, and when they settled again the curlew sandpipers all settled together, and slightly segregated from the dottrel. Most of the specimens I have obtained have had some signs of summer plumage, though none has had the full breeding-dress.

Its nest had not been found until July, 1897, when the bird was discovered breeding in the Yenisei Valley.

In conclusion, I wish to express my thanks for the very valuable assistance I have received, in preparing this paper, from Mr. Gilbert Archey, Canterbury Museum. He did all the nomenclature, and helped me with the identifications.

Art. 36.—*Marine Littoral Plant and Animal Communities in New Zealand.*

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[*Read before the Wellington Philosophical Society, 30th September, 1921; received by Editor, 16th November, 1921; issued separately, 18th May, 1923.*]

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I. THE LITTORAL BELT.

From an ecological standpoint the dividing-line between sea and land is high-tide mark, which usually sharply defines the limits of terrestrial and marine life. Not infrequently there is an intervening space in which no life is found. Thus Hedley (1915, p. 61) notes that in the vicinity of Sydney there is a fairly wide vacant space between the highest mollusc and the lowest lichen. But in New Zealand, perhaps owing to its temperate climate, with many cloudy days, and consequent diminished degree of insolation, an overlapping of marine and terrestrial life frequently takes place. In the north the gasteropod *Melaraphe unifasciata* occurs on rocks associated with the lichen *Xanthoria parietina* and the glasswort *Salicornia australis*. In the south *M. cincta* as well occurs above

the lower limit of terrestrial vegetation, whilst where fresh water flows over the rock *M. cincta* and *Notoacmea pileopsis* are found by the side of fresh-water algae. The varied forms of animals and plants occurring between tide-marks may be accounted for by the wide range of conditions prevailing there as the result of the regular alternations in the amount of water supplied by the semi-diurnal rise and fall of the tide. Within this belt are found representatives of all classes of organisms, ranging from fishes to unicellular algae, and the one character by virtue of which they are classed together is their ability to endure periods of complete submergence as well as to tolerate exposure to the air for a portion of each day. The richest community in the intertidal belt is that of large brown algae, and extends between the limits of low-water, spring and neap tides. This is really only the upper margin of an extensive submarine forest, but being represented above low-tide mark it will be included in the present account.

In defining ecological provinces in the littoral belt, all authors I have consulted, with the exception of Southern and Hedley, divide it into horizontal divisions variously called "belts," "regions," or "zones." But this cuts across a more fundamental division based on communities of plants and animals present. These depend, in the first place, on the nature of the substratum—whether rock on the one hand, or sand and mud on the other. Hence Southern (1915, p. 16) speaks of a "microlithic" and a "macrolithic" substratum, recognizing these as dividing the benthos into two fundamental groups; but I cannot follow him further in his complicated table (p. 17), in which the nature of the bottom and the vertical position are so used that a single association, such as *Zostera*, occurs in three places. Hedley divides the littoral belt into four types of beaches—namely, shingle, sand, estuarine, and ocean-reef. The rock and microlithic communities may be divided into horizontal belts determined by tidal levels, but these belts do not necessarily correspond in the two regions. For instance, the upper limit of the lowest intertidal formation on rocks, that of large brown algae, is low-water level, neap tides; but the corresponding limit of the grass-wrack formation, which extends upwards from fairly deep water on mud, is about half-tide mark. According to my observations, there are three recognizable belts between tide-limits, including that area within the wash of storm-waves. These I call the high-tide, mid-tide, and low-tide belts, and use the word "littoral" as applying to all that portion of the shore between the highest wash and the lowest level of spring tides. I am unable to adopt the terminology of any other author, as none to whose work I have had access defines his belts in terms of tide-levels. The belts of Johnston and York (1912, p. 2) appear to correspond most nearly with those here defined.

The upper limit of the mid-tide belt corresponds roughly with the upper limit of fixed animals. The lower limit of this belt is perhaps better defined, and coincides with the upper limit of large brown algae, such as *Carpophyllum maschalocarpum*, *Xiphophora chondrophylla*, *Marginaria boryana*, and others. Above this line many marine animals are never found. Conversely, many littoral animals keep strictly within tide-marks. The animals confined to the littoral belt are mainly sedentary and fixed species, derived from marine forms, but so adapted to regular drying and wetting that they are absent from situations not exposed by the tide. For instance, in rock-pools between tides I have noticed that the common rock-barnacle,

Elminius modestus, will not grow, whereas it is found in abundance on the rock above the water-line. The following are examples of species not found below low-water level, neap tides: *Modiolus pulex, Cellana ornata, Melaraphe unifasciata, M. cincta, Chamaesipho columna, Lepsiella scobina, Ostrea cucullata.* There appears to be nothing in common among these species, unless it be their usually small size, and, of course, their ability to retain water within the shell.

But in dealing with the relations between terrestrial and marine life interest naturally centres in those members of the Pulmonata which have returned to the littoral belt. The New Zealand species belonging to this group are the following: *Phytia ornata, Marinula filholi, Leuconopsis obsoleta, Amphibola crenata, Siphonaria australis, S. obliquata, S. zelandica, Gadinia conica*, and various species of *Onchidella*. *Amphibola crenata* inhabits mud-flats between tides; it avoids *Zostera* beds, and can tolerate a considerable admixture of fresh water with the salt; it occurs usually fairly near high-tide mark. In Tauranga Harbour it is often found among *Juncus maritimus*, and is a constant member of the mangrove association. Living in mud, these animals are in no danger of being absolutely dried while the tide is out. Farnie (*Trans. N.Z. Inst.*, vol. 51, p. 71) records that if left without any water at all they will not live more than a day; but they can live for a month completely immersed in sea-water. The same author, in describing the entrance to the lung, states that the lower lip is produced outwards into an inferior deeply grooved pallial lobe which is capable of closing against the upper lip of the pulmonary aperture. *Siphonaria obliquata* is found abundantly on rocks between tide-marks. It appears to be most common from Cook Strait southwards. It usually occurs in greatest numbers near high-tide mark, where it is found in clusters in crevices and rock-pools. The anatomy of this species has been studied by Cottrell (*Trans. N.Z. Inst.*, vol. 48, p. 582), who describes the respiratory orifice as being bounded above by the mantle and below by the body-wall differentiated to form a muscular valve. The animal thus has the power of opening and closing the pulmonary orifice. *Siphonaria obliquata* also possesses a gill, so that aeration of the blood is continuous whether the animal is submerged or not. If the species is correctly classified as a pulmonate, the gill will be a secondary adaptive character. In *Gadinia* the pulmonary cavity has become aquatic, though there are no branchiae. *G. conica* lives low down in the tidal belt, hiding in crevices and beneath ledges. *Phytia ornata* occurs on the edge of mangrove swamps and other muddy places near high-tide mark. *Leuconopsis obsoleta* is found under stones in similar situations. *Marinula filholi* is found sparingly among stones near high-tide mark, and higher up (under terrestrial growth, as noted below) at Island Bay. I have also found many thousands of young clustered together under stones between tide-marks at Makara, Cook Strait. *Onchidella* occurs abundantly between tide-marks. These animals are stated to close their pulmonary orifices while under water and open them when exposed to the air.

Assuming the origin of terrestrial from marine life, the route from sea to land has usually been considered as taking what is probably the easiest way—namely, by entering estuaries and undergoing the process of change in reed and mangrove swamps. In such places the passage from salt to fresh water is gradual: terrestrial vegetation invades the shallow water, and sheltered conditions obtain. The only mangrove-plant in New

Zealand is a form of *Avicennia officinalis*, not extending south of latitude 38° S. Animals living a semi-terrestrial existence here are *Amphibola crenata*, *Potamopyrgus antipodum*, *Phytia ornata*, *Helice crassa*, and certain amphipods. The same forms live in similar situations in salt marshes. But a more direct route over a sandy beach might be taken by such crustacea as *Talorchestia quoyana*, and others which occur under seaweed cast up during storms. The rocky coast, too, provides a means whereby marine animals can change their habitat for a terrestrial existence. Members of the family Littorinidae provide examples of gasteropod molluscs living in stations reached only by spray from the waves. Unlike the majority of shelled animals between tide-marks, they do not habitually hold water within their shells during the retirement of the tide, but seal themselves up behind their opercula, and attach the peristome of their shells to the rock by means of a mucilaginous secretion. An interesting summary of the habits of Littorinoids in this connection is given by Hedley (1915, p. 33). The New Zealand members of this family, *Melaraphe unifasciata* and *M. cincta*, have already been mentioned as advancing up the rocky coast to beyond the lower limit of land vegetation. More success, however, appears to be achieved by gasteropods in crossing the rocky shore where patches of succulent plants are found beyond high-water mark. At Island Bay, Cook Strait, occurs a plant-formation consisting chiefly of a low dense growth of *Selliera radicans* and *Triglochin striatum*, where soil has collected in hollows among the rocks well beyond the reach of the tides. By searching carefully among this, *Marinula filholi* and *Acmella neozelanica* may be found in abundance. The former, however, is a pulmonate occurring between tide-marks.

OCEAN CURRENTS.

The shores of New Zealand are washed by at least two distinct ocean currents. The Antarctic drift current, which has a general set towards the north-east, affects chiefly the southern and eastern coasts as far north as Jackson's Bay on the west and Banks Peninsula on the east. From Jackson's Bay the current flows southward along the coast and through Foveaux Strait. Drift from the south of New Zealand has been cast up on the Chatham Islands; there are certain points of agreement, too, between the fauna and flora of the same two localities. This current appears to be pushed off shore by a current, presently to be described, passing through Cook Strait from the west. The second ocean current reaching New Zealand is probably a continuation of the Notonectian current which, after flowing southward down the east coast of Australia, is diverted eastwards on coming into contact with the Antarctic drift current about the latitude of Tasmania. Crossing the Tasman Sea, it impinges against the west coast of New Zealand, and is again in the main deflected to the northward, and, passing round the northern part of New Zealand, continues in an easterly or south-easterly direction. Winds no doubt cause diversions, in the surface layers at any rate, as logs from northern New Zealand rivers are frequently cast up at the Kermadec Islands. A current passes eastward through Cook Strait, part of it coasting southward to Banks Peninsula and the remainder continuing in a south-easterly direction off shore. The current crossing Tasman Sea possibly has some influence, accounting for the supposed more equable climate on the west coast of New Zealand as compared with the east coast. To the effect of this

current also may be attributed the sundry visitors from the tropics recorded from time to time from the coast of New Zealand north of Raglan and the Bay of Plenty. Among the drift may be mentioned the fruits of *Barringtonia*, whilst stragglers amongst animals include the green turtle (*Chelone mydas*), leathery turtle (*Dermochelys coriacea*), common sea-snake (*Hydrus platurus*), and ringed sea-snake (*Platurus colubrinus*). (See Cheeseman, *Trans. N.Z. Inst.*, vol. 40, p. 167.)

Local surface currents on the coast of New Zealand are determined mainly by tides. The flood tide runs eastward through Foveaux Strait and northward along the coast of New Zealand and through Cook Strait. In Hauraki Gulf, however, it flows south. On the west coast of the North Island the flood tide runs south as far as Cape Egmont, with a northerly diversion in Taranaki Bight. Past Cape Campbell it is westerly. Ebb tidal streams are the reverse of these.

Sea-temperature.

There is a considerable difference between the temperature of the sea in the north and in the south of New Zealand. The annual range for each locality, however, is about the same—namely, 8°–9° C. The dependence of the temperature of the surface of the sea on that of the air is well shown by the annexed graph, which is compiled from Anderton's report mentioned below. While the curve of sea-temperature follows that of the air, its amplitude is much less, and the maxima and minima usually follow extremes in the atmosphere.

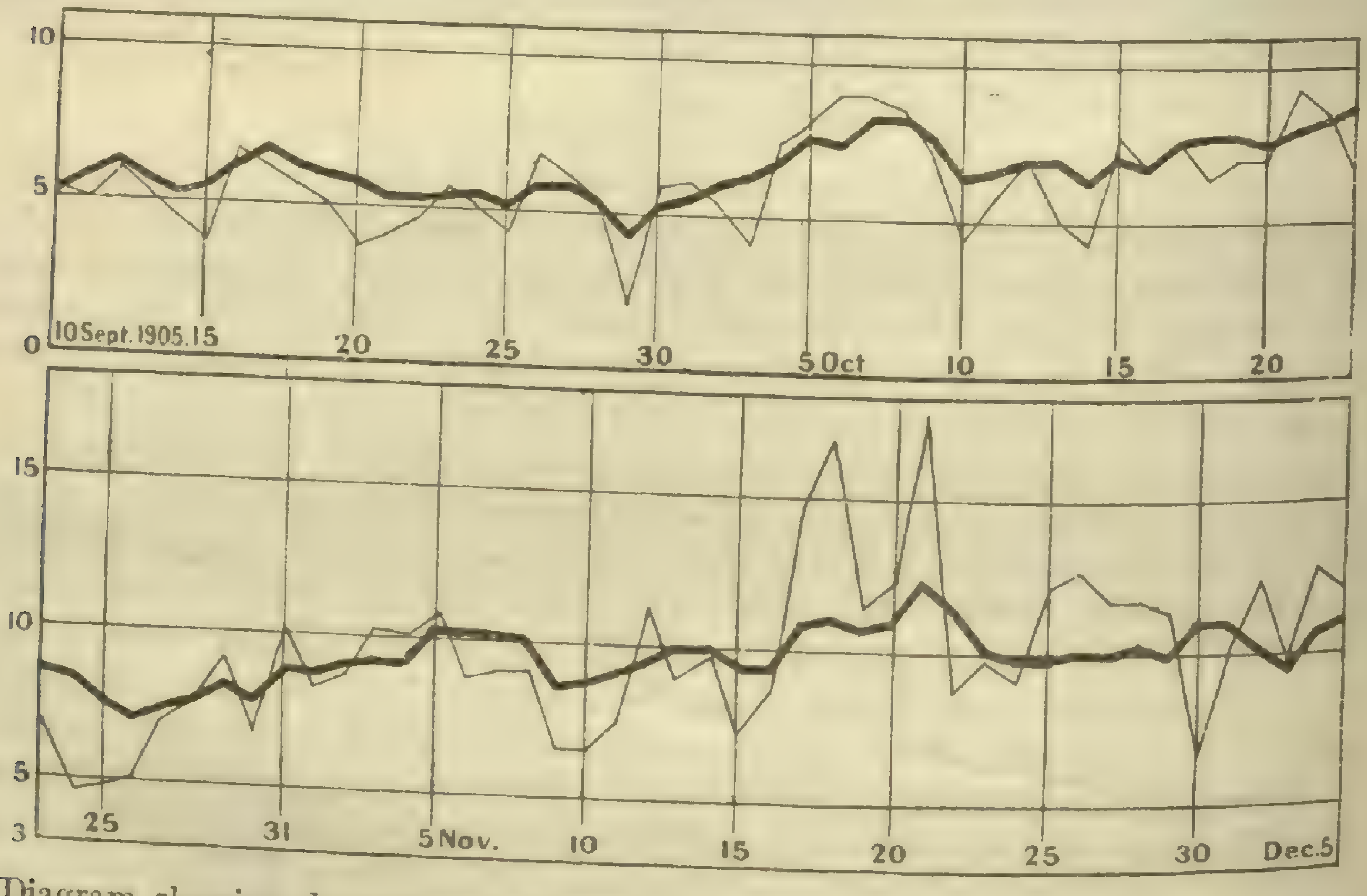

Diagram showing dependence of sea-temperature (thick line) on air-temperature (thin line), Portobello.

I give herewith a table showing air- and sea-temperatures for a period of a year at Auckland, Wellington, and Dunedin. The figures for Auckland were kindly supplied me by Mr. W. H. Hamer, M.Inst.C.E., Engineer to the Auckland Harbour Board. Those for Portobello were taken by Mr. T. Anderton, and recorded in *Trans. N.Z. Inst.*, vol. 38, p. 354. The Wellington records were made by myself.

Auckland (Queen's Wharf), Forenoon.		
Date.	Air.	Sea.
1914.	Deg. C.	Deg. C.
Jan. 12	20·5	21·1
26	22·8	20·8
Feb. 9	22·8	19·4
Mar. 9	20·5	20·3
23	20·3	20·3
April 6	21·1	20·0
22	18·8	17·7
1913.		
May 5	13·3	14·2
12	14·7	13·3
27	16·1	12·8
June 16	14·4	11·4
30	12·2	10·5
July 14	15·5	11·1
28	15·0	11·1
Aug. 12	15·8	12·5
26	13·9	12·2
Sept. 9	14·4	13·0
22	16·4	14·2
Oct. 6	16·4	17·2
20	18·8	15·5
Nov. 3	17·7	17·5
17	20·5	17·7
Dec. 1	18·0	16·6
15	18·3	17·5
29	22·5	18·8

Wellington (Worser Bay), 9 a.m.		
Date.	Air.	Sea.
1922.	Deg. C.	Deg. C.
Jan. 1	14·7	14·7
8	18·6	16·0
22	14·0	14·7
29	15·5	15·0
Feb. 5	14·4	14·4
12	19·4	16·4
19	19·2	15·5
26	20·6	17·0
Mar. 5	15·8	15·5
12	19·4	16·5
19	17·2	15·5
26	17·2	15·5
April 2	11·8	14·8
9	14·7	15·1
16	14·0	14·4
23	12·2	13·3
1921.		
May 8	14·0	12·8
15	12·2	11·0
22	13·4	11·4
29	13·4	12·0
June 5	11·0	9·8
12	14·0	11·0
19	12·0	11·0
26	12·2	10·8
July 3	13·3	10·7
10	9·4	9·4
17	14·4	11·4
24	9·4	9·1
31	10·2	9·7
Aug. 7	8·0	10·0
14	12·8	10·6
21	12·6	10·3
28	10·3	10·0
Sept. 11	12·8	10·9
18	10·5	11·2
25	13·6	10·6
Oct. 2	14·4	12·2
9	13·0	12·2
16	13·6	12·8
23	14·0	13·3
30	14·2	12·5
Nov. 6	13·8	12·8
13	15·0	14·0
20	15·0	13·3
27	13·2	12·6
Dec. 4	12·2	13·2
12	16·6	15·0
18	15·8	14·0
25	17·5	14·4

Dunedin (Portobello), 9 a.m.		
Date.	Air.	Sea.
1905.	Deg. C.	Deg. C.
Jan. 1	10·0	11·6
8	11·4	9·8
15	14·0	11·8
22	13·8	12·4
29	12·2	11·0
Feb. 5	15·8	14·2
12	14·8	14·6
19	13·0	13·2
26	10·0	11·8
Mar. 5	13·2	12·4
12	11·8	12·6
19	9·8	11·4
26	9·4	10·0
April 2	12·0	11·4
9	7·8	8·2
16	9·8	8·8
23	6·2	6·6
30	6·0	6·6
May 7	8·2	7·6
14	5·8	6·2
21	4·6	5·2
28	2·8	4·0
June 4	0·2	2·0
11	3·8	2·8
18	1·0	2·8
25	3·6	3·8
July 2	4·0	3·2
9	0·4	3·0
16	1·4	3·0
23	7·8	3·2
30	3·6	3·4
Aug. 6	1·6	3·6
13	4·4	3·6
20	2·4	3·6
27	3·4	4·0
Sept. 3	6·0	5·4
10	5·2	5·0
17	6·2	6·8
24	5·0	5·4
Oct. 1	6·0	5·4
8	8·6	8·2
15	7·8	7·0
22	8·6	8·2
29	9·0	8·2
Nov. 5	10·8	10·2
12	11·2	9·4
19	11·4	10·8
26	12·6	10·0
Dec. 3	9·8	9·6
10	12·0	12·0
17	10·0	11·6

The temperature of the water in rock-pools between tides is appreciably raised on a sunny day, as the following figures show :—

Locality.	Temperature in Sea.	Temperature in Rock-pool.
	Deg. C.	Deg. C.
Lyttelton Harbour	16·5	18·5
	9·5	10·5
	13·0	14 0
Taylor's Mistake (near high-tide mark) ..	15·6	19·0
	12·0	16·6

Tides.

In the Southern Ocean, south of the continental masses, the tidal wave has a clear course round the world, and from here appear to generate tides supplying the great oceans to the northward. In New Zealand the tide comes from the south, striking the south-west coast of the South Island about 12 o'clock at full and change of the moon. On the west coast it apparently meets a portion of the previous wave which has passed through Cook Strait from the east. Its course up the east coast, however, is more eventful. In two hours it has passed through Foveaux Strait from west to east, and after another hour is abreast of Taiaroa Head. Four hours after its first incidence on the New Zealand coast it has reached Lyttelton and Wellington, and after a further two hours has passed through Cook Strait in one direction and towards Napier in another. The northern branch continues round the East and North Capes and down the west coast of the North Island, reaching New Plymouth about 10 o'clock. The moiety that passes through Cook Strait from the eastward meets this northern branch in one direction south of Cape Egmont, and in another continues in a westerly course past Cape Farewell and meets the next incoming tidal wave southward of this.

The amplitude of the tide depends almost entirely on the configuration of the land. Thus at points where the tidal wave can sweep past, as in Foveaux Strait, Cook Strait, and the east coast, its range is not great. Spring tides rise at Wellington 4½ ft., at Napier 4 ft., at Taiaroa Head and Gisborne 6½ ft. Where the land converges, as in Hauraki Gulf and Tasman Bay, the effect is to bank up the water as the sea-space becomes narrower, hence such high tides as at Auckland, 12 ft., and Nelson, 12 ft. Perhaps the meeting of tides from two directions accounts for the high tides experienced on the west coast, as at New Plymouth, 11 ft., and Grey River, 10 ft.

Highest spring tides sometimes follow the full moon and sometimes the new moon. Thus at Auckland, in 1914, from January to May full moon was followed by good spring tides, but from August to December the highest tides followed the new moon.

II. Ecological Relations.

Light.

Quantity.—Certain facts in the distribution of plants and animals in the intertidal belt may be attributed in part at least to the effect of light, though it is difficult to say whether in avoiding the sunny side of a rock

the organism is being influenced more by the drying effect of the sun than the intensity of the light. By observing the distribution of algae with regard to the orientation of the rock-surface above and below low-tide mark it is evident that light can be only a secondary factor, the principal cause of organisms seeking shade being the moisture associated with it. For instance, *Codium adhaerens,* always a shade-plant between tides, is almost uniformly distributed over rocks not exposed at low water. *Caulacanthus spinellus* is a shade-loving species that is found well up in the emerging belt. (Plate 43, fig. 1.) Among light-avoiding animals two may be mentioned as being invariably found in shady places—namely, *Notoacmea pileopsis* and *Atalacmea unguis-almae.* Both agree in having thin shells, that of *Atalacmea* being almost transparent. *N. pileopsis* occurs at high-tide mark, *Atalacmea* near low-water mark. Related animals, *Notoacmea septiformis* and *Patelloidea stella corticata,* both with thick shells, live exposed to the brightest light. Many animals, such as *Turbo smaragdus, Monodonta aethiops, Cellana radians,* and *C. ornata,* seem not to mind bright light. Others habitually avoid it, though their shells may be as thick as those of the species just mentioned. Shade dwellers are *Monodonta lugubris, M. atrovirens,* and all the Amphineura save only *Sypharochiton pellisserpentis.* The bright-green algae *Ulva rigida, Chaetomorpha Darwinii, Caulerpa sedoides,* and *C. Brownii* flourish in the most brightly illuminated situations, and, moreover, present the maximum amount of chlorophyll-bearing tissue to the light—*Ulva* by its wide wavy thalli, *Chaetomorpha* and *Caulerpa* by having the green layer only on the outside of turgid segments of elongate or branched thalli. (Plate 42, fig. 1.) Rock-pools perhaps afford a test as to light-enduring qualities, for here the air-drying factor does not enter. Growing in full daylight in such situations is *Corallina officinalis,* its thalli usually partially bleached. Related species (*Amphiroa, Melobesia*) live below low-tide mark, and are characteristic shade-loving plants found abundantly beneath the fronds of *Durvillea* and other large brown algae. Generally speaking, green and brown algae grow in full daylight, but red algae avoid bright light. As some of the species above mentioned are dominant in their associations, it follows that light is one of the factors determining the distribution of some of the littoral communities. *Bostrychia* and *Caulacanthus* near high-tide mark are light-avoiding; *Corallina* and *Hormosira* are light-tolerating; *Ulva* and *Enteromorpha* appear to be light-seeking.

A difference is noticed in the colour of *Corallina* and *Amphiroa* corresponding to the degree of exposure to light: species living in shady situations are full-coloured, while those exposed to bright light are always much paler. In the same plant the colour is seen to change from light on the outside branches to a deeper shade of red or purple in the lower branches, which receive less light.

The shells of *Brachyodontes maorianus* are brown when living in shaded positions, such as under stones or under the base of *Lessonia,* but when exposed to full light are of the normal bluish-black colour. *Siphonaria australis* appears to be but the shade form of the darker *S. zelandica.*

Quality.—It is well known that sea-water has a filtering action on light passing through it; in other words, light rays are absorbed in different degrees according to their wave-lengths. Red rays, for instance, are absorbed more quickly than blue or violet. The different-coloured pigments with which the chlorophyll is masked in algae are usually assumed to be related to the varying quality of light at different depths,

and their distribution in the main supports this view. Thus bright-green algae are usually highest in the series, dark-green and brown algae predominate about low-tide mark, whilst red algae are most plentiful below this. The red pigment is presumed to check the harmful action of the actinic violet rays, which are proportionately stronger at a little depth than at the surface. But there are many exceptions to the order in which the classes of algae usually occur. Thus *Bostrychia arbuscula* and *Caulacanthus spinellus*, which occur highest in the intertidal belt, belong to the Rhodophyceae, while *Chaetomorpha* and *Caulerpa* are bright-green algae found amongst red algae at low-tide mark.

There appears to be a relation similar to that observed in algae between the colour of the tests of tunicates and the quality of the light received. On exposed rocks the predominant colour is some shade of brown, which may have a similar function to that of brown pigment in the Phyaeophyceae. *Boltenia pachydermatina*, which lives at a lower level, is of a red colour not unlike that of the Rhodophyceae. Under stones the tests are colourless, with a pink or reddish tinge (*Corella*), or distinctly blue (*Styela caerulea*).

Evaporation.

(*a*.) *Shelled Animals*.—Undoubtedly the main character by virtue of which animals are able to conserve moisture during the retirement of the tide is an external shell. The shell, by reason of its usually great strength, is probably primarily intended for defence; but that it functions largely as a retainer of water is indicated by the fact that, with few exceptions, all animals habitually exposed to the atmosphere between tides possess shells. The shell proper is invariably composed of carbonate of lime, either in the form of arragonite or calcite, or both. It varies very much in shape, is possessed by animals widely sundered in systematic position, as molluscs and polychaet worms, and is consequently diverse in origin. One of the distinguishing features of the phylum Mollusca is the mantle, and it is this organ which secretes the shell, mainly by its edge; but additions to the thickness of the shell are made internally by the portion of the mantle behind its outer border. That there is a direct relation between the presence of a shell and the amount of exposure to air to which the animal is subjected may be inferred from the fact that many molluscs living below low-tide mark have no shell, or only a small one covering portions of the viscera (*Scutus ambiguus*, nudibranchs, pleurobranchs). Others in similar situations have only rudimentary opercula (*Alcithoe*, *Struthiolaria*).

Gasteropoda.—The gasteropod shell takes three main forms:—

(1.) It is conical, with a wide base and the apex somewhere in the median line (*Cellana*, *Notoacmea*, *Siphonaria*, *Tugalia*, *Gadinia*). The gills, or, in the case of *Siphonaria* and *Gadinia*, the openings to the branchial chamber, are situated near the margin of the shell. When immersed the animal raises its shell off the rock and allows the water to circulate underneath, where it serves the purpose of respiration. These limpet-like animals are mainly vegetable feeders, and do not move about the rocks to any extent. When the tide retires, the shell is appressed to the rock-surface sufficiently tightly to prevent the enclosed water from escaping, and thus the animal remains in a bath of salt water until the return of the tide.

(2.) The shell is ear-shaped—that is, it has a broad elliptic base several times longer than the height, and the apex is spiral and marginal. There is a row of branchial apertures along a lateral carina (*Haliotis*). The provision for conserving moisture is here obviously imperfect, and these animals are therefore rarely found above low-tide mark.

(3.) The shell takes the form of a cone spirally twisted and fused into a fusiform or turbinoid shape, with the last turn or body-whorl usually capable of being closed by an operculum. The animal can withdraw itself entirely within the shell. The greater number of gasteropods possess a shell of a spiral form. Regarded from the point of view of holding water when the aperture is applied to a flat surface, these shells may be arranged in two classes—those with a continuous peristome, and those having a canal in front. In species with the peristome in one plane the body-whorl can be kept full of water by the animal keeping it close to the rock, much after the manner of a limpet, and this is the method practised by those gasteropods which habitually remain in exposed positions between tides (*Nerita*, *Monodonta*, *Turbo*). *Lepsiella scobina* has a very small notch in front, and is able to hold water in its body-whorl in a similar way to the species just mentioned. In the case of the second class, those with a well-developed notch or canal in front, that portion of the animal included in the canal would come in contact with the air if exposed by the tide. These animals, represented by *Neothais*, *Cominella*, *Euthria*, *Verconella*, and others, are found about low-tide mark, or on mud and sand flats between tides, where they partly bury themselves when the tide is out. *Alcithoe arabica*, *Cominella adspersa*, and *Ancilla australis* have large open canals, and frequent sand-flats, where they creep along just beneath the surface, thus keeping the animal moist while the sand is exposed to the air.

Pelecypoda.—In the Pelecypoda the shell consists of two valves laterally disposed, and meeting more or less along their edges. On rocks between tides the principal pelecypods belong to the Mytilidae and Ostreidae (*Modiolus*, *Mytilus*, *Ostrea*); the valves fit closely along their margin except, in the Mytilidae, at one point on the ventral side; but here the organ of attachment, the byssus, passes through, so that the animal is enabled to keep the shell full of water while the tide is out. Pelecypods living in sand or mud between tides usually have shells with valves fitting closely all along the margins (*Amphidesma*, *Antigona*, *Tellina*, *Myodora*). Others (*Pinna zealandica*, *Panopea zealandica*, *Cochlodesma angasi*) have widely gaping shells, and these live at or below low-tide mark. Thus the perfection with which the two valves of the shell fit bears a relation to the position of the animal in the intertidal belt, and, as with gasteropods, though the pelecypod shell is primarily a weapon of defence, it is essential as a conserver of moisture to those animals regularly left dry by the tide.

Thyrostraca.—The sessile cirripedes have a truncated conical shell composed of four or six plates fused together and fixed to the rock. The shell thus forms a more or less circular box, open only at the top. Here there is a large aperture closed by four shelly plates embedded in the integument of the animal. The plates are arranged two on each side of the median line, and are capable of being pushed outwards by the animal, when they part along the central line and the modified branchial apparatus is extruded like a net and scoops water into the shell. When the tide is out the aperture is closed by the tightly fitting valves, and the animal, as in molluscs, remains in a bath of sea-water.

Amphineura.—The shell is composed of eight overlapping shelly valves, the ends of which are immersed in a leathery girdle. Only two species, *Sypharochiton pellisserpentis* and *Plaxiphora caelata*, habitually remain in dry situations while the tide is low, and these species have the girdles protected by shelly scales or close-set bristles. The arrangement of the gills is similar to that of *Cellana*—namely, in a circle more or less complete near the inner

edge of the shell. Water is retained within the branchial chamber precisely as in limpets.

Brachiopoda.—The lamp shells possess two shelly valves placed dorsally and ventrally, the animal being attached to the rock by a muscular peduncle passing through an aperture or notch in the ventral valve. These animals do not expose themselves to view, preferring the under-sides of rocks. *Terebratella rubicunda* is found just above low-tide mark, but from its position is subject to very little drying.

Polychaeta.—Extensive patches on rocks between tides are covered with the colonies of the tubicolous polychaet *Vermilia carinifera.* The animal is enclosed in a thick shelly tube closed by an operculum. Another worm, *Hermella spinulosa*, forms dense colonies near low-tide mark. Its tubes are composed of grains of sand cemented together, and are packed closely at right angles to the rock so that only the outside ends are exposed.

(*b.*) *The Operculum.*—The origin and subsequent history of the operculum in the Gasteropoda would make an interesting study. Probably it was first developed as an article of armour behind which the animal could retire when danger threatened, but it appears also to have a definite relation to the water-conserving requirements of the animal. In those gasteropods reaching highest up in the littoral belt—namely, *Melaraphe unifasciata* and *M. cincta*—the operculum is used to seal up the animal during the long periods these species remain out of water. It is horny in texture, and closely fits the aperture. During periods when the animal is more active it retains moisture in its body-whorl; but, often living in situations above high-tide mark, it appears to pass into a semi-dormant states, and retires behind its operculum. The operculum, therefore, is habitually used as a conserver of moisture. In the belt between high- and low-tide levels all the gasteropods except the naked *Onchidella* are able to close the aperture of the shell by a closely fitting operculum. In *Nerita, Natica, Astraea,* and *Turbo* it is shelly; in the remainder it is horny. But the operculum is not usually used for the purpose of retaining water, this being done by the animal applying the peristome of the shell to the rock-surface. If, however, the shell gets displaced and the water flows away, the animal may seek a moist spot, or else draw in behind its operculum until the tide overtakes it. Coming now to low-tide mark, we find on rocky coasts that the operculum is usually normally developed in the spiral shells. Here, perhaps, life is strenuous and protection needed; but on sand-flats the operculum becomes reduced so that it can no longer close the aperture (*Struthiolaria, Alcithoe, Ancilla*). The animals here have developed burrowing habits, enabling them to escape the notice of their enemies, and, as the sand is always moist, tidal changes do not affect them to the extent that it does animals living on rocks. The operculum has ceased to be useful either for defence or to conserve moisture, and has become rudimentary.

(*c.*) *Protection of Gills.*—Other than cirripedes, the only crustacea exposing themselves to drying conditions in the intertidal belt are crabs. Small amphipods and isopods remain at the roots of algae, within the body-whorls of gasteropod shells, or buried in sand. In crabs the carapace is sharply reflected at the sides and extends under the thorax so as to form a chamber on each side, outside the attachment of the legs. In the enclosed spaces so formed are situated the gills, to which water enters only by narrow slits at the bases of the legs, and so in these nearly closed chambers the gills are kept quite moist while the crab is running about the rocks.

(*d.*) *Coriaceous Tests.*—Many animals living near low-tide mark, and consequently exposed for short periods each day, do not secrete shells, but

the integument assumes a tough, leathery texture, and allows a certain amount of drying without injury to the soft parts within. In such cases the mouth and gill-openings can be be closed by a sphincter. Members of the class Tunicata are commonly found a little distance above low-water mark. Those living under stones, such as *Styela caerulea* and *Corella*, have a rather soft test or tunic, colourless, white, pink, or bluish, and sometimes nearly transparent, so that the viscera can be distinctly seen through it.

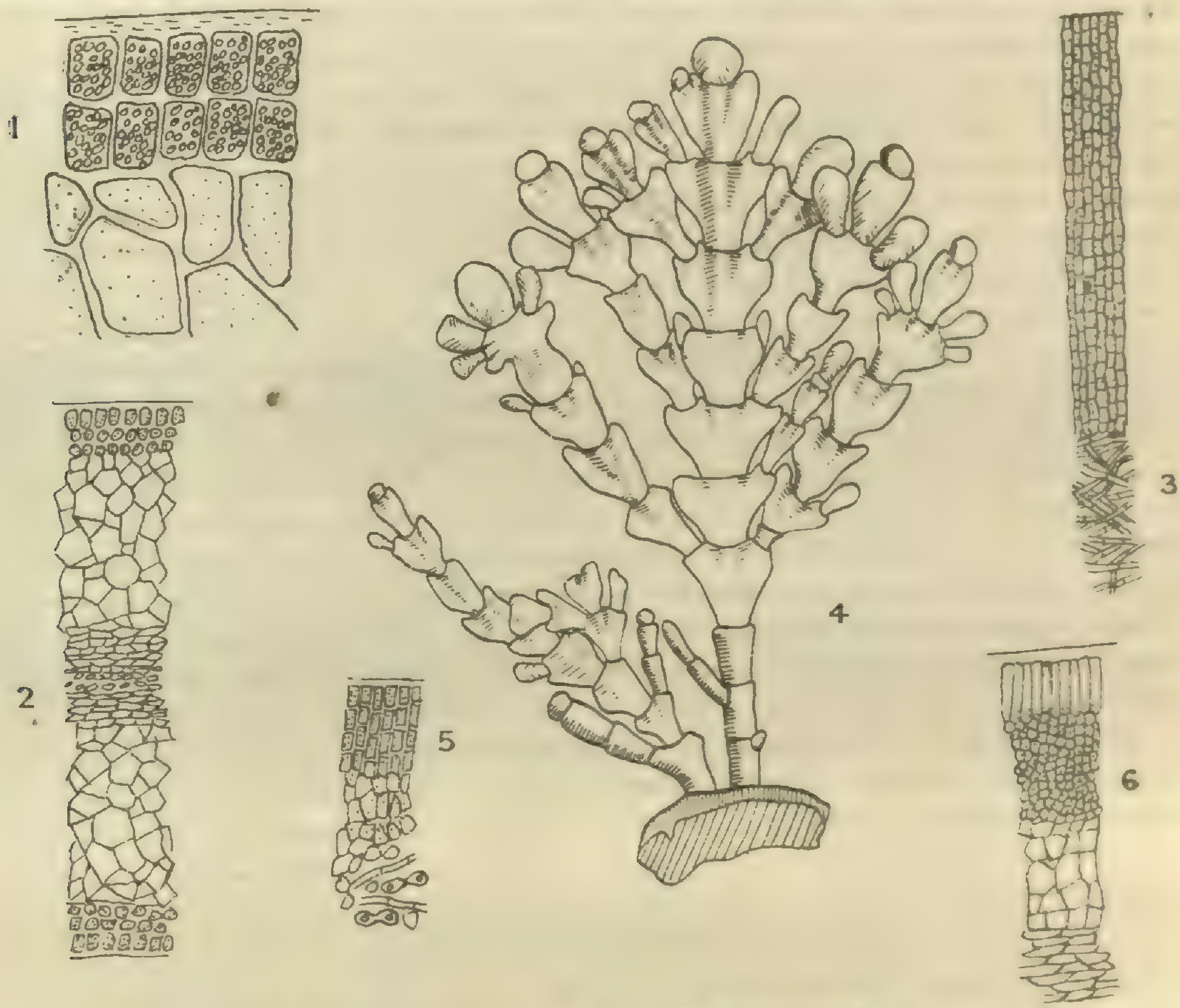

FIG. 1.—Part cross-section of thallus of *Cystophora dumosa*.
FIG. 2.—Cross-section of thallus of *Lessonia variegata*.
FIG. 3.—Part cross-section of cortex of *Durvillea antarctica*.
FIG. 4.—*Amphiroa corymbosa*, an alga whose thallus is permeated with carbonate of lime.
FIG. 5.—Half cross-section of thallus of *Xiphophora chondrophylla*.
FIG. 6.—Half cross-section of thallus of *Carpophyllum maschalocarpum*.

Tunicata living on rocks between tide-marks, on the contrary, possess a tough cuticle, usually of a brownish colour (*Polycarpa*, *Cynthia*), but sometimes red (*Boltenia*). The cuticle lies outside the ectoderm, and can stand a considerable amount of drying. It has been found in the British species of *Ascidia* to consist largely of cellulose, a substance characteristic of plants, but rare in animals. One end of the test is fixed to the rock-surface; the opposite end contains two apertures or siphons which can be opened and closed at the will of the animal. Sea-water passes in through the oral siphon, and after passing through the pharyngeal stigmata and peribranchial cavity is discharged through the atrial siphon.

Common naked molluscs occurring between tide-marks are *Onchidella nigricans* and *O. patelloides*. The body is oval, with an arched back covered with a tough skin, somewhat slimy. These animals are able to remain out of water without harm, though usually they seek shady crevices in the

rocks. They are air-breathers, and the pulmonary orifice which opens in the posterior portion of the under-surface of the body is closed while the animals are under water. The Onchidellae may be contrasted with nudibranchs and aplysoids, which live at or below low-tide mark and have the branchiae but little protected and on the upper surface of the body.

(*e.*) *Algae.*—In algae the main protection against atmospheric conditions is dense thick-walled tissue on the outside of the thallus. Thus in *Bostrychia arbuscula* the outer layer is composed of thick-walled polygonal cells containing olive granules. In *Cystophora dumosa* there are one or more rows of oblong cells with their long axes at right angles to the periphery, and with moderately thick cell-walls. Within this layer is large-celled parenchyma. *Lessonia variegata* has on each side of the thallus-lamina three or four rows of minute densely aggregated cells with clear walls and olive-brown granules. Within these is a transparent tissue of large cells, and in the centre a band of mechanical tissue. A dense outer cortex followed by large-celled medullary tissue is also found in *Durvillea antarctica*, *Carpophyllum maschalocarpum*, and *Xiphophora chondrophylla*, descriptions of which are given under the heading of the associations of which they are the dominant members. (See figs. 1–3, 5, 6.)

(*f.*) *Water-reservoirs in Algae.*—Two species of brown algae living well up in the intertidal belt have a hollow thallus filled with a watery substance. In *Hormosira Banksii* the internodes are swollen and filled with water. In *Splachnidium rugosum* the central space is continuous and contains a watery jelly. In *Adenocystis utricularis* and *Colpomenia sinuosus*, which live nearer low-tide mark, the whole thallus is saccate and filled with water.

(*g.*) *Covering of Slime or Mucilage.*—Many algae have a covering of slime on the outside. *Splachnidium rugosum* and *Codium adhaerens* are exceedingly slimy. *Ulva* and *Porphyra* possess a thin coat, which on drying is slightly sticky to the touch. A covering of slime is frequent in many marine animals.

Sea-water.

(*a.*) *Buoyancy.*—As with land-plants, algae are so constructed as to display their vegetative structure as much as possible to the surrounding medium and to the light. On account of the movement of the water, rigid tissue is inadmissible in the littoral belt except for very-low-growing forms (*Corallina*, *Melobesia*). Devices for keeping algae upright in the water are of the nature of buoys, and may be special air-vesicles, expansions of the thalli, or large air-cells. The air-vesicles vary in shape and position. In *Cysptophora*, *Marginaria*, and *Carpophyllum* they are globose and terminate short branches. In *Macrocystis pyrifera* it is the stalks of the leaf-like fronds that are enlarged into elongate pyriform vesicles. Large air-cells are best seen in *Durvillea antarctica*, where they are polygonal and columnar, stretching across the frond at right angles to the plane of the lamina.

(*b.*) *Acidity.*—Erosion in molluscan shells has been ascribed to acidity in the water by nearly all authors who have written on the subject (Lewis, *Bost. Soc. Proc.*, vol. 6, p. 149; Tryon, *Struct. Syst. Conch.*, vol. 1, p. 19, 1882; Cooke, *Cambr. Nat. Hist.*, vol. 3, p. 276, 1895). The observations here recorded appear to support this view. Erosion almost invariably begins on the apex of gasteropods or umbones of pelecypod shells—that is, on those parts which are longest exposed to the action of the air or water. To strengthen the parts of the shell thus worn thin

the animal will secrete layers of nacreous tissue inside, or, as occurs in many exotic fresh-water forms, abandons the apical whorls and closes the lumen behind the last occupied whorl. Erosion is prevented in those species which can cover the shell with the mantle (*Ancilla*) or those possessing a periostracum (*Cymatium costatum*, *Calliostoma*).

Sea-water is not appreciably acid, but fresh water always contains dissolved carbon-dioxide, and where its influence is felt along the sea-shore the shells of molluscs are more or less eroded. Always associated with fresh water, too, is decaying vegetation, and acids evolved from the decomposition of this may assist in eroding shells. Thus in estuaries most of the shells of mollusca are more or less eroded. *Monodonta corrosa*, *Cominella lurida*, *Cerithidea bicarinata*, and many others might be mentioned. Further details will be given when describing the mud-flats and mangrove associations. Molluscs exposed between tide-marks, and therefore to the influence of rain, are usually more eroded than those found below low-tide mark;

On the north coast of Rangitoto is a pool into which the sea penetrates through a bank of shingle. The water is brackish, and contains many animals. The shells of these are all more or less eroded, even the dorsal surface of *Asterina regularis* having a whitish appearance, due to the action of the water on the tips of the plate-spines.

At White Island, Bay of Plenty, the overflow from the crater-lake, which is charged with about 5 per cent. of free hydrochloric acid, enters the sea in Crater Bay, on the south side of the island. There is no life where the stream enters the bay, but about a hundred yards away *Nerita melanotragus*, *Cellana ornata*, *C. radians*, and *Notoacmea septiformis* are found on the rocks. The shells of all these species are heavily eroded; in some of the shells of *Nerita* the whole of the black outer layer, with the exception of a narrow strip along the margin of the aperture, has disappeared. (Plate 42, fig. 2.) All the shells also have a rusty-brown deposit on their exposed surfaces.

Edaphic Factors.

Rock.

(*a.*) *Attachment of Plants.*—The larger algae are attached by disc-shaped holdfasts, the bases of which follow the irregularities of the rock-surface, to which they closely adhere. The medium by means of which the alga retains its hold is in most forms the gelatinous tissue of the cell-wall, but in the corallines the thallus is firmly cemented by a deposit of lime. In *Durvillea antarctica* the holdfast is solid unless hollowed out by marine animals, which is usually the case. In *Macrocystis pyrifera* and *Lessonia variegata* it consists of a mass of stems, terete and forming a dense network in *Macrocystis* (Plate 42, fig. 7), but in *Lessonia* taking the form of radiating plates like the plank-buttresses of a tree. In certain algae the whole thallus is crustaceous and closely appressed to the rock (*Leathesia*).

(*b.*) In those fixed animals with calcareous shells the shell is firmly cemented to the rock, following its irregular surface. The base of the shell is usually expanded, thus giving a larger holding-area (*Chamaesipho columna*, fig. 9). Those pelecypods which are fixed to rock are attached by one valve or part of a valve. The shells are therefore always more or less irregular. In *Ostrea* the left valve is attached; in *Anomia* it is the right valve, but it has a large sinus on its upper border through which passes a plug-like byssus.

Fixed animals not possessing calcareous shells, such as tunicates, are attached by their leathery tests, the base of attachment being always

expanded and conforming to the irregularities of the rock-surface. Other methods of attachment are a pedicel passing through a foramen in one valve of the shell (brachiopods), the base of the column or body-cavity of sea-anemones, and a byssus consisting of strong threads (Mytilidae).

(*c*.) Certain adjustments of sedentary animals to the rock-surface may be mentioned here. Limpet-like shells have their margin irregular: occasionally in *Cellana radians*, always in *Gadinia conica* (fig. 7) and *Siphonaria zelandica*. The genus *Crepidula* provides examples in which the plane of the aperture is convex or concave according to the surface on which the species live. *C. costata* is usually found on rocks, and the contour of the peristome viewed from the side is concave; but in *C. crepidula* it is convex when within the disused shells of gasteropods, and concave when attached to the outside. The latter is the more usual, and shells of this shape are often considered to form a distinct species (*C. monoxyla*).

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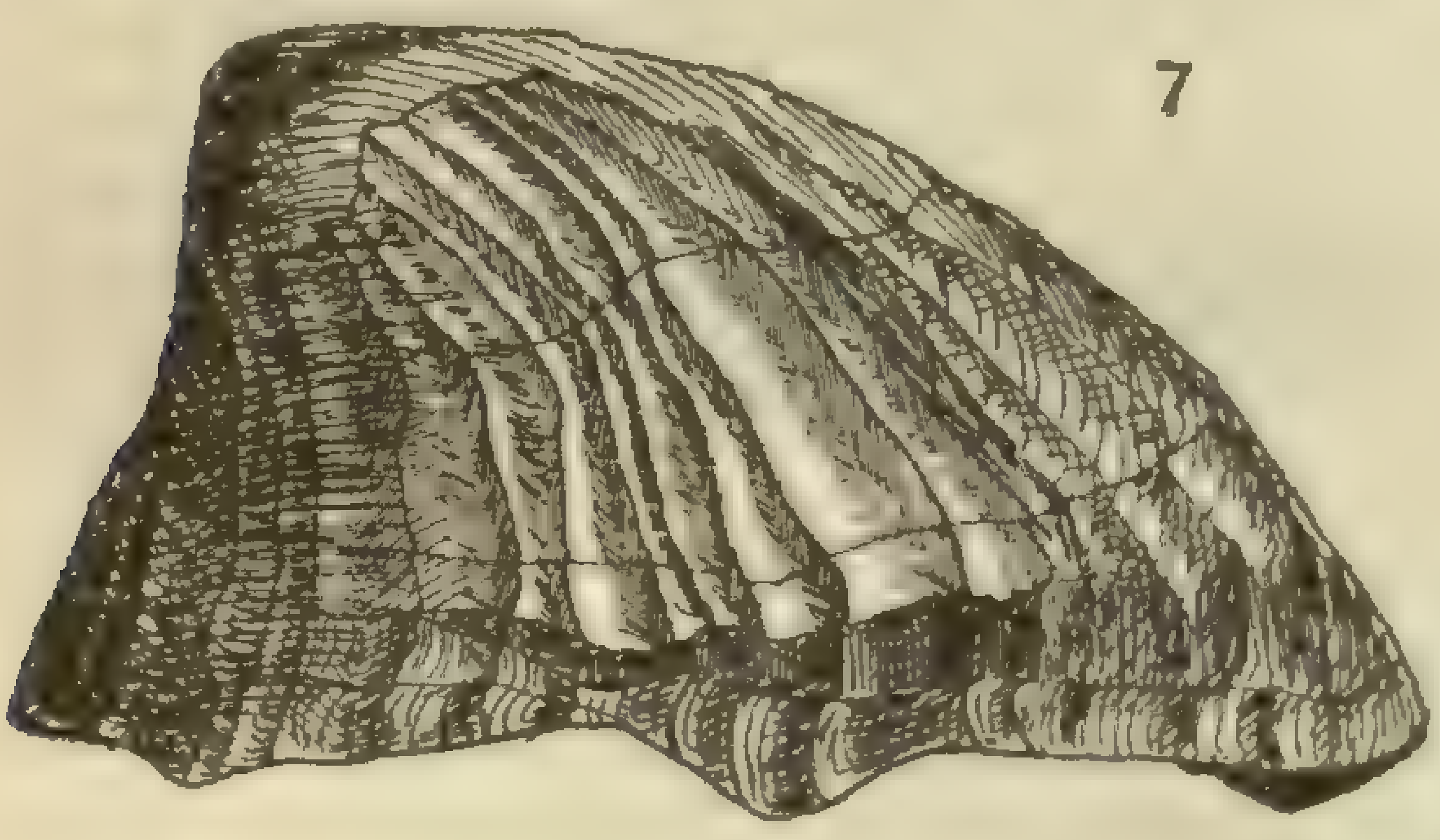

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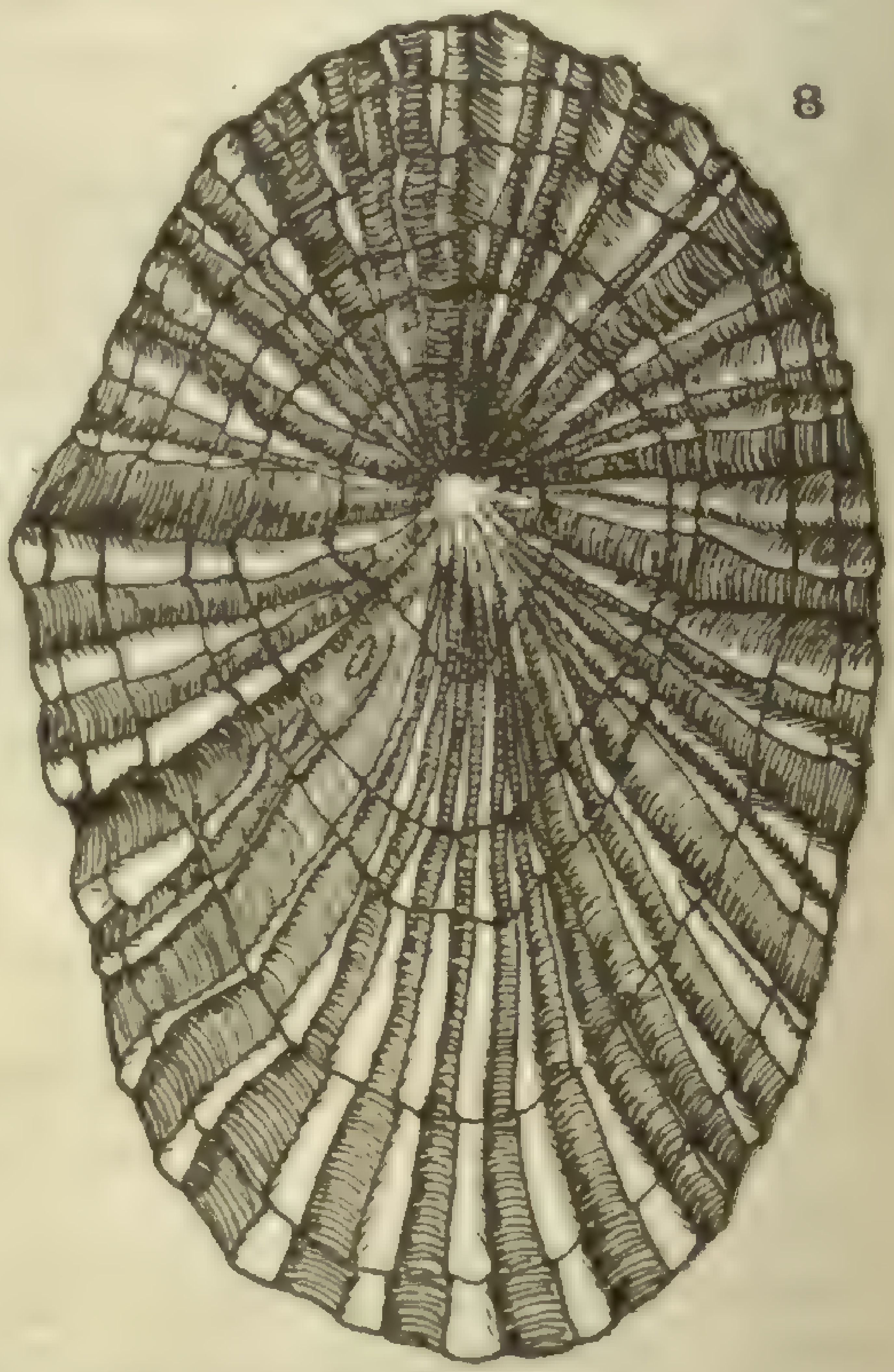

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Fig. 7.—*Gadinia conica*, Taylor's Mistake. Shell with irregular peristome.
Fig. 8.—*Siphonaria obliquata*, Shag Point. Shell strengthened with heavy ribs.
Fig. 9.—*Chamaesipho columna*, Island Bay. Sessile barnacle with tent-like form of shell.

Siphonaria zelandica adjusts the shape of its shell to the rock-cavity in which it settles. If this is a hollow which can accommodate the animal the tent-like form becomes superfluous, and consequently the shell is flat. Should the shell in growing encounter a piece of rock on one side it stops short, but continues as usual elsewhere; hence one-sided shells are sometimes found. *Gadinia conica* is also occasionally found with the apex near a truncated margin.

Fishes of the family Gobiosocidae have the ventral fins modified into suckers. (Plate 42, fig. 5.) *Diplocrepis puniceus* and *Trachelochismus pinnulatus* are common species among rocks in the surf belt. But what appears to be a more remarkable case of adjustment in fishes to the rock-surfaces is exhibited by *Acanthoclinus littoreus*. This fish lives between

tide-marks, frequenting the under-side of stones, where it remains in wet mud or shallow pools while the tide is out. Its median fins, both dorsal and anal, are long, with rays of even height. The tips of all the rays except those at the posterior ends are swollen. It is suggested that these swellings are special organs, possibly sensitive, for pushing against the rocks above and below, and are thus an adaptation to the fish's habit of wriggling its way along under stones. (Plate 42, fig. 6.)

(*d.*) *Rock-borers.*—Many animals burrow into the softer kinds of rocks, and probably have organs especially adapted for this purpose, though their methods are not well understood. *Pholadidea spathulata*, *Barnea similis*, and *Lithophaga truncata* are found commonly boring into Tertiary sandstones in Rangitoto Channel. The entrance is in every case smaller than the main portion of the burrow, so that the animal is a prisoner. The method of enlarging the burrow has been observed in the exotic genus *Pholas*: the animal rasps the rock with its shell. *Lithophaga* has an acid-secreting gland, presumed to be the source of a solvent for dissolving limestone rock (Calman, *Rep. Comm. Inst. Civil Eng.*, 1920, p. 73). A small crustacean, *Sphaeroma quoyana*, is also very abundant, boring into the same rock as the bivalves mentioned.

Sand.

The main character of a sandy beach, so far as the life found there is concerned, is its movement, caused by wave-action. Only animals capable of burrowing quickly can exist in the surf-swept shore. Hedley has pointed out that the shells of sand-dwellers are solid, smooth, and tapering, citing *Donax deltoides* of the New South Wales coast as an instance. The truth of this statement is borne out by the character of two species of *Amphidesma* found in New Zealand, both of them being inhabitants of the ocean-beach. The foot is large and powerful, and the shell tapers gradually towards the anterior end, thus offering little resistance to the sand. The siphons are long—indeed, those of *Amphidesma ventricosum* can be extended to 15 cm. or 20 cm., so that the animal may remain with its shell at this depth below the surface and so minimize the risk of being thrown up by the surf. But not all sand-dwelling pelecypods have smooth tapering shells. On the ocean-beach near Tauranga, where *Amphidesma subtriangulata* exists in countless thousands, there also occurs associated with it, in numbers equally great, *Antigona spissa*, a small species with ventricose shell roughened by concentric ribs.

Brittle-stars inhabiting the sand-beach are furnished with extremely long, thin arms. *Amphiura aster* at Timaru, and the same or an allied species in Rangitoto Channel, remain with their bodies buried in the sand at a depth of 10 cm., but the tips of the arms project above the surface, and attend to the wants of the animal below. Polychaets are rapid burrowers, as any one who endeavours to dig them out soon discovers. Gasteropods living in sandy beaches are in the habit of ploughing their way along just below the surface. The foot is frequently large, with its lobes reflected partly over the shell (*Ancilla, Natica*). In *Struthiolaria* it is similarly very broad.

The pelecypod *Pinna zelandica* in Rangitoto Channel is found buried upright in sand. Passing downwards between the valves near the anterior end is a large byssus composed of numerous spreading threads, to the extreme end of each of which is fastened a grain of sand.

Mud.

Animals.—Some of the adaptations of pelecypods to a muddy substratum form an interesting contrast to those of species living in sand. Again I refer to Hedley's interesting paper (1915, p. 50), where a ventricose rough shell, a small foot, and no siphons are given as characteristics of the mud-dwelling *Arca trapezia* of Sydney Harbour. An exactly parallel case is afforded by *Antigona stutchburyi* of New Zealand muddy estuaries. The shell is swollen and but moderately thick, and roughened with concentric and radiating ridges; the animal is furnished with a small foot and short siphons. But it must be pointed out that these characters are not universal in mud-dwelling pelecypods, for *Amphidesma australis* associated with *Antigona* has a compressed, smooth, solid shell.

A type of gasteropod shell characteristic of intertidal mud-flats is the turreted form. A heavy shell of this shape can be dragged over mud or sand, but would be very inconvenient on a rough rocky surface. *Cerithidea bicarinata* is an example. Better instances of this relation could be quoted from outside New Zealand—for example, the heavy *Pyrazus* on mud in Australia, and the more massive *Terebra* on sandy bottoms in the tropics.

Plants.—Zostera nana and *Z. tasmanica*, covering extensive areas on sheltered mud-flats between tides, are furnished with rhizomes which spread horizontally beneath the surface and give off roots which are often matted. Further, the covering of leaves above the surface protects the mud from the scouring action of tide and waves. *Avicennia officinalis*, a tree growing in muddy estuaries as far south as Tauranga and Raglan, sends up erect respiratory roots, or pneumatophores, in order to provide sufficient aeration for its root-system.

MOVEMENT OF WATER.

Perhaps the most potent of factors in the littoral belt with which the inhabitants have to contend is the movement of water. Tidal currents are the cause of the more gentle and steady movements along a coast; in an estuary, however, they may be very strong and exert a powerful action on the flats, masses of *Zostera* being frequently torn away and carried out to sea. The most violent action of the sea is caused by waves which reach their maximum strength during storms. The power of the surf may be gauged by the damage done by heavy seas to breakwaters and other harbour constructions. The most characteristic modifications of plants and animals inhabiting the intertidal belt appear to be adaptations caused by the motion of water. This is shown by their shape, strength, pliancy, and by their devices for holding on to objects. Hedley has noted the tent-like form and the strength of molluscan shells on the rocky coast of New South Wales (1915, p. 58). Some adaptations to water-movement observed in animals and plants in the littoral belt in New Zealand will here be described.

(1.) *Tent-like Form.*—To offer least resistance to the surf the animal must be attached to the rock by a broad base, have sloping sides and a fairly low apex. Hence results the tent-like form so prevalent on rocky coasts, and independently acquired by members of several classes of animals.

(*a.*) Gasteropoda.—A conical shell with a more or less oval base characterizes the members of the Patellidae, Acmeadae, Siphonariidae, and the genera *Tugalia* and *Gadinia*. There is an apical foramen in *Fissuridea* and *Puncturella*, and an anterior marginal slit in *Emarginula*.

(*b.*) Amphineura.—In proportion to basal area members of this class offer less resistance to the surf than do the tent-like gasteropods. The

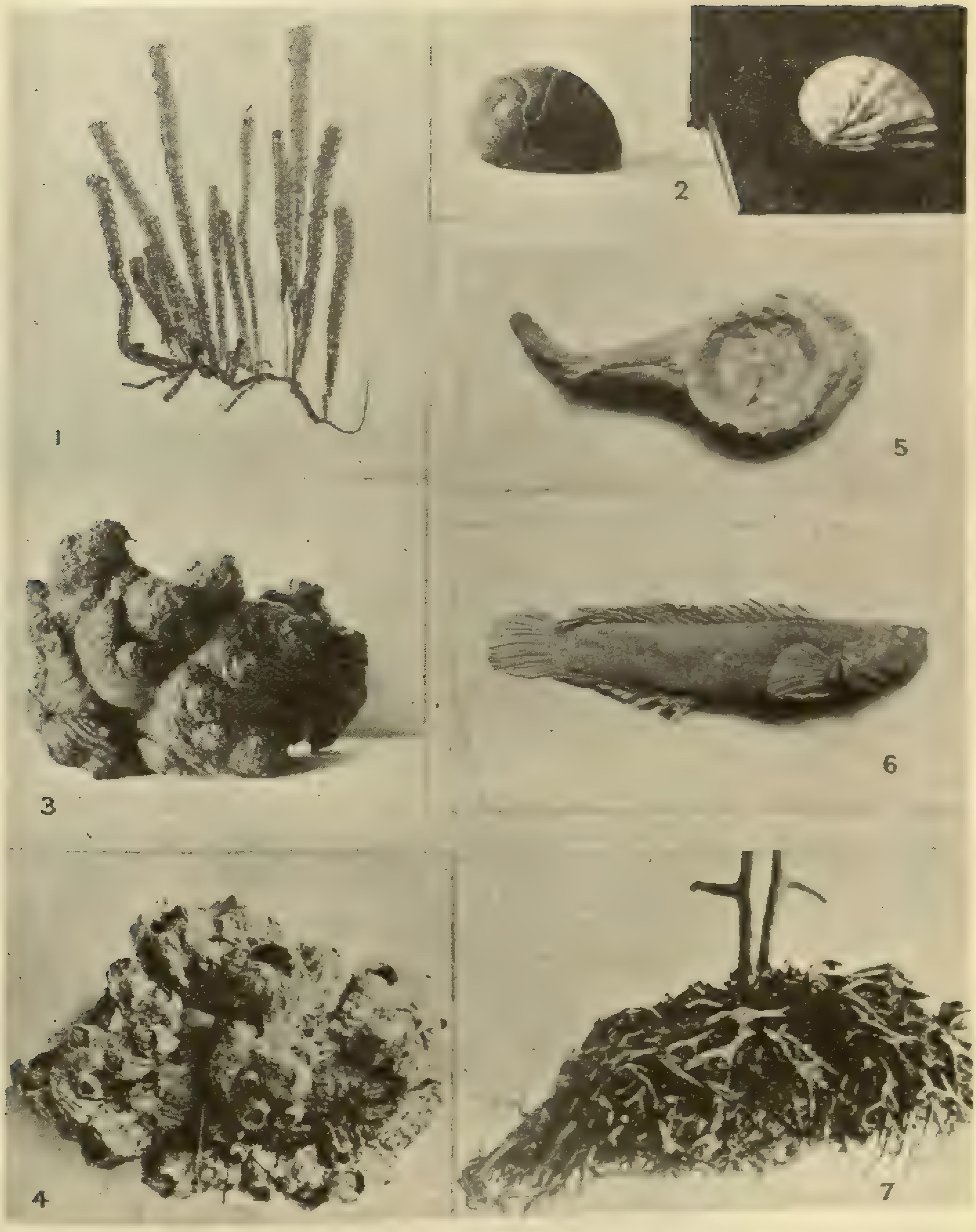

FIG. 1.—*Chaetomorpha Darwinii*, a green alga with turgid thallus, growing at low-tide mark.
FIG. 2.—*Nerita melanotragus*. Normal and eroded shells.
FIG. 3.—Cluster of the gregarious tunicate *Cynthia* from Auckland Harbour.
FIG. 4.—Cluster of *Elminius plicatus* on shell of *Mytilus planulatus*.
FIG. 5.—*Diplocrepis puniceus*. Under-surface, showing sucker formed of modified pectoral and pelvic fins.
FIG. 6.—*Acanthochinus littoreus*, a fish that lives under stones between tide-marks.
FIG. 7.—Holdfast of *Macrocystis pyrifera*, a kelp-weed growing in deepish water.

shell is composed of eight overlapping valves set in a leathery girdle. Species living in the most exposed situations are *Sypharochiton pellis-serpentis*, *Plaxiphora biramosa*, *P. oblecta*, *P. caelata*, and *Eudoxochiton nobilis*: a depressed form is characteristic of all these.

(*c*.) Thyrostraca.—Among the commonest and most exposed animals in the littoral belt are the sessile cirripedes. The shell is more or less conical with the base, much expanded in some species (*Chamaesipho*, *Tetraclitus*), firmly cemented to the rock. All the species are commonly found in clusters, where the shape of each individual shell is adjusted to its neighbours, and a fairly even surface, offering little or no resistance to the waves, is thus formed by the united summits (fig. 9).

(*d*.) Fishes.—Species of the family Gobiesocidae are surf-fishes admirably adapted to their station—firstly, by a broad ventral sucker formed from the modified pelvic and pectoral fins, and, secondly, by their depressed form. Head on to the waves, *Diplocrepis puniceus* would offer as little resistance as a limpet.

(*e*.) Stelleroidea.—The only echinoderms commonly exposing themselves to the surf are the starfishes *Patiriella regularis* and *Stichaster australis*. *Patiriella* is pentagonal in form, and depressed. The edge of the disc being close to the rock, this species remains in perfect security while the sea passes over it. *Stichaster* is a many-rayed form that is capable of sticking to the rock so firmly that a considerable amount of force is required to dislodge it.

(*f*.) Pelecypoda.—*Ostrea cucullata* in exposed places has the whole of the outside of the left valve cemented to the rock; the right valve is but little arched, so that the waves sweep harmlessly by. *Mytilus* and *Modiolus* by their byssi are less securely attached. They, however, congregate in dense clusters and present a smooth wedge-shaped surface to the surf.

(2.) *Strength of Shell.*—The shells of many marine animals are solid and thick (*Nerita*, *Turbo*, *Monodonta*, *Vermilia*); others are reinforced by ridges (*Cellana*, *Siphonaria*, *Neothais*, *Antigona*, *Elminius*) (fig. 8), or knobs (*Verconella*). Animals having large thin shells, as *Calliostoma tigris*, *Tonna cerevisina*, *Phalium labiatum*, do not live in situations exposed to the surf.

(3.) *Pliancy.*—Instead of resisting the force of the surf by means of a rigid form of special shape or strength, some animals boldly stretch themselves up from their base of attachment and rely on the pliancy and toughness of their integument, which allows them to follow moving water without harm to themselves. The best example of this is *Boltenia pachydermatina*, common about low-tide mark from Cook Strait southwards. This animal grows among large brown algae, swaying to and fro with them. Its stalk, composed of a tough leathery integument, is 6–8 mm. in diameter and 50 cm. or more in length. The stalked cirripedes *Scalpellum villosum* and *Polinices spinosus* can perhaps be included in the present category, though their peduncles are short and they prefer the protection of rock-crevices.

All the large brown algae have thick, pliant stems. These are by no means their weakest points, for when torn off during storms it is usually the bases of attachment which separate from the rock. It is only necessary to mention the thick but pliant stems of *Durvillea antarctica* and *Eclonia Richardsoniana*, the thinner and very tough stems of *Marginaria*, *Carpophyllum*, *Xiphophora*, and *Lessonia*, and the extremely long rope-like stems of *Macrocystis pyrifera*.

(4.) *Plant-form.*—Ribbon-like form of the leaf or thallus is characteristic of most marine plants, the degree of dissection varying with the movement

of the water. The thalli of *Durvillea antarctica* on exposed coasts assume the form of long narrow segments of nearly even width throughout. In more sheltered situations the thallus is broadly and irregularly palmate. *Xiphophora chondrophylla*, perhaps the most abundant species of brown algae occurring at low-tide-mark, has the thallus-segments uniformly narrow. In the size of the "leaves" of *Carpophyllum* an interesting comparison may be made between *C. maschalocarpum*, which grows in fairly exposed placed and has small thick leaves, and *C. phyllanthus*, which affects harbours and sheltered inlets and is a very luxuriant form with large thin leaves. *Macrocystis pyrifera*, which possesses the largest and most easily torn leaves of the brown algae, occurs chiefly inside harbours, especially in tidal streams, and in deep water outside the break of the surf.

The ribbon-like leaves of *Zostera* and *Ruppia* need only be mentioned here. These plants live in stations subject to tidal currents, but not to much wave-action. The action of waves is irregular and discontinuous, whereas that of currents is regular and constant, and this is reflected in the difference between branched and unbranched stems. Mr. W. A. Scarfe informs me that the ribbon-like form of *Durvillea antarctica* only occurs in places where current is added to wave-action.

(5.) *Hooked Claws.*—Certain crustacea living on algae exposed to the surf are provided with sharp claws, which enable them to retain their positions while the seaweed is being buffeted about by the waves. Their use is in every respect similar to that of the hooks possessed by various crustacea living on fishes and cetaceans. Species of *Idotea* occur on various algae in the surf belt; their legs all terminate in hooked claws. *Amphoroidea falcifer* is found on *Durvillea antarctica*, and by its depressed form and strong hooks is admirably adapted to its station.

Organic Environment.

(1.) *Armour.*—Perhaps the most universal of devices for protecting sedentary marine animals against enemies is the possession of shelly armour. This is probably the primary use of shell and operculum. But, as I have pointed out in a previous paragraph, these are also of service in the littoral belt for conserving moisture. Hermit-crabs, which have the hinder portion of the body quite unprotected, make use of empty gasteropod shells.

(2.) *Weapons.*—Closely associated with armour are weapons of defence and attack. The chelae of crabs may be first mentioned. Powerful jaws are possessed by many polychaet worms; gasteropods employ their radulae for boring through the shells of their prey. The spines of echinoids and the stinging-cells of sea-anemones are effective weapons.

(3.) *Distasteful properties* are possessed by many animals and plants. The common sponges are quite unpalatable, owing to the presence of siliceous spicules. Their evil smell also probably helps to keep off would-be enemies, whilst the bright colour of many of the species perhaps serves as a warning to other animals. The calcareous deposits in *Corallina*, *Amphiroa*, and *Melobesia* render them safe from the depredations of herbivorous animals (fig. 4).

(4.) *Assimilative Colouring.*—Instances of patterns of colouring resembling the surroundings, be it rock or algae, among which the animals live are frequent in the littoral belt, and are presumed to be mainly for protective purposes. Fishes of the families Blennidae and Gobiesocidae are of various shades of black, grey, and pink with a mottled pattern. Nudibranchs and

tectibranchs are sometimes of mottled greys like *Pleurobranchus novaezealandiae*, or reddish-brown with darker blotches as in *P. ornatus*—that is, they resemble the surroundings generally. Others are so coloured as to resemble only the algae or sponge on which they are found. Thus *Ctenodoris flabellifera* is yellow, and *Rostanga rubicunda* bright scarlet. and these are found on sponges similarly coloured. The free sea-anemone *Phlyctenactis retifera* is coloured olive-brown like *Cystophora dumosa*, on which it lives. Crustacea are green (*Paridotea ungulata*), brown (*Amphoroidea falcifer, Idotea elongata*), or red (*Paridotea peronii, Dynamenella huttoni*), according to the colour of the algae on which they are found. The sucker-fish (*Trachelochismus guttulatus*), living in the brown-algae formation in Wellington Harbour, is olive-brown. Finally, some shrimps are colourless.

(5.) *Masking.*—Deliberate masking by carrying pieces of shell, seaweed. or stones is practised by the sea-urchin *Evechinus chloroticus.* Certain crabs (*Paramithrax*) place on their carapaces pieces of seaweed, which become fixed and grow, forming little gardens, completely masking the crabs, which, knowing the protection afforded, usually keep in places where seaweed is growing. I once watched one of these crabs walking across the sandy bottom of a pool. On coming into my shadow it suddenly stopped, paused for a moment, then hurried back to the seaweed-covered rocks.

Many animals have their shells or tests (Tunicata) masked by algae, *Vermilia*, barnacles, sponges, and other forms of life. These probably merely settle uninvited on the vacant space. Nevertheless, they must subserve to some extent the purpose of concealment. Mud- and sand-dwelling pelecypods (*Pinna, Antigona, Amphidesma*) frequently have the posterior projecting end of their shells covered with various forms of marine growth. Too much growth on the shells sometimes results in the destruction of both the mollusc and the life it supports. In the Bay of Plenty, after a storm, it is a common thing to find *Venericardia purpurata* with the sponge *Chalina* 30 cm. or more in length washed up on the beach.

(6.) *Animals and Plants.*—Some animals appear to be specially modified for attachment to algae. When *Siphonaria australis* lives within the base of the holdfast of *Durvillea antarctica* it is usually found on the roof of the chamber, occupying hollows in the algal tissue. Here the foot of the mollusc fills up the hollow and projects beyond the shell-margin, the shell itself becomes depressed sometimes to the point of becoming quite flat, and the margin is slightly recurved.

Notoacmea scapha is found in Tauranga Harbour living on the leaves of *Zostera nana.* Its narrow shell seems a special adaptation to this station. The hooks of the isopods *Idotea* and *Amphoroidea* for holding on to algae have already been mentioned.

III. BIOTIC COMMUNITIES.

Animals and plants inhabiting the littoral belt are found to group themselves in communities, many of which are sharply separated from one another. These I refer to as "biotic communities" because, whatever the limits assigned to them, whether from a consideration of the species they include or of the habitats, it is found that in every case both plants and animals form integral parts. The term "growth-form" has been defined as including all those species which agree in their external form, anatomical structure, and behaviour. A biotic community consists of a definite set of growth-forms in relation to a definite habitat. The growth-forms occur

in definite relation to each other as well as to the inorganic surroundings. In the environment there are many factors involved in climate and substratum, and the different combinations of these give many different habitats. Because, therefore, of differences in the external conditions, and of the dominance of certain growth-forms and different relationships of others, there arise many distinct communities of plants and animals.

Formations.

The reporters to the Commission of Phytogeographical Nomenclature (Brussels, 1905) recommended that a plant-formation should be defined as composing associations of species which differ in their floristic composition but are in agreement, firstly, with the conditions of the habitat, and, secondly, as regards their growth-forms. Were this definition applied strictly every community having a different growth-form as its dominant member would be considered a different formation. In a New Zealand forest there are several different growth-forms in trees, and we might accordingly have many forest formations, such as those where *Agathis*, *Beilschmiedia*, or *Nothofagus* are dominant. In the littoral belt the multiplicity of formations so defined would be very great. Because of the diverse origin of the plants and animals inhabiting it, there are many growth-forms that are dominant in certain areas. Now, different growth-forms often require the same amount of water and the same quantity and kind of food supplied to them daily—that is, they bear similar relations to their surroundings. To use an expression of Shelford's, they may be said to be ecologically equivalent in respect to a given factor. These physiologically similar growth-forms, hereafter referred to as ecological groups, appear to be the important units concerned in the differentiation of formations. I would therefore define a formation as a biotic community having its ecological groups in definite combination and in relation to a definite environment. Examples of growth-forms ecologically equivalent, and therefore belonging to the same ecological group, will show the importance of the physiological requirements of the organism being taken into account, and the small value that can be placed on external features, which, however, may be so different as to justify separation into distinct growth-forms. A sessile cirripede (*Elminius*), a pelecypod (*Mytilus*), and a polychaet worm (*Vermilia*) may grow side by side, existing under precisely the same conditions as regards supply of moisture and exposure to the surf, and each will filter water through its branchiae or other organs for the same period each day, and will digest similar minute organisms. Each also can efficiently protect itself against the drying effects of exposure while left uncovered by the tide. These animals, which are widely sundered systematically, have quite different growth-forms, but belong to the same ecological group. Similarly, the algae *Hormosira Banksii* and *Scytothamnus australis* are ecologically equivalent as regards ability to endure exposure to the atmosphere. Yet each is differently constructed for this purpose: the one has an internal water-reservoir, the other a protective covering of tissue that reduces transpiration; and they thus belong to different growth-forms. It is the ecological groups that I have utilized to define the formations between tide-marks. For instance, the shelled-animals formation always has for its dominant member an animal capable of conserving moisture in its shell while exposed to the atmosphere. Such an animal may be a cirripede, a pelecypod, a gasteropod, or a polycheat worm.

There are certain constant spatial relationships among the growth-forms in each formation. In the microlithic substrata two or three main tiers of

life are recognized—namely, the subsurface, or burrowing, organisms; the surface, or crawling, animals; and, when a plant is dominant, the supra-edaphic plant-form and its dependent life. On rocks in the shelled-animals formation there is usually only a single stratum of life with a fixed or sedentary animal dominant. If the rocks are broken there may be an assemblage of animals underneath the stones, usually differing markedly from those above, and forming a subformation dependent on the damp conditions. The intertidal formation possessing the greatest variety of growth-forms is that in which large algae are dominant. Associated with these are animals and plants on the rock-surface, in crevices, and under stones, on the thalli of the algae, and, when *Durvillea* is present, peculiar assemblages of animals inhabitating cavities in the discoidal holdfasts. Each formation may therefore be said to have a definite structure depending on the nature of the substratum and the dominant growth-form.

As some formations appear to be more closely related than others, it may be convenient to group them into classes. These I call "series," and they are characterized by the physiological requirements of the dominant ecological groups. Formations may likewise be divided into subformations according to the dominant growth-forms. Thus the shelled-animals formation includes four subformations—pelecypod, sessile cirripede, tubicolous polychaet, and gasteropod. Each of these comprises one or more associations which are communities of definite floristic and faunistic composition. Differences in the principal species might be utilized to define subassociations, but I have not treated the subject in such detail in the present paper.

Classification of Littoral Biotic Communities.

An animal-and-plant formation has been defined as a biotic community with its principal ecological groups in definite combination and in definite relation to the habitat. The community is thus looked at from the point of view of its growth-forms and environment, and one formation is distinguished from another by a difference in the dominant ecological group of growth-forms. The dominant growth-forms in the littoral formations are always fixed animals and plants deriving nutriment from the sea-water, including its microscopic life, or else sedentary animals living on small benthic organisms. Carnivorous and herbivorous animals which feed on other large animals or plants can never be dominant forms in any permanent association. The number of tiers or strata in a formation depends primarily on the substratum, which may be impenetrable to plants and animals alike, as rock, or it may be easily burrowed into by animals or penetrated by the roots of plants, as sand and mud. This difference is fundamental, as, though formations are interchangeable on a microlithic substratum on the one hand or on rock on the other, according to supply of moisture, the formations of mud and sand can never invade a rocky coast, nor can the opposite change take place. Littoral formations, therefore, can be classed under two main heads—(1) Formations on rock with the dominant form varying from algae to shelled animals according to the diminishing supply of water. Animals and plants firmy fixed to the rock-surface are the main features of the rock-formations. (2) Formations on sand and mud, varying from animal to plant according to height above low tide—that is, in the reverse order to that observed in rock-formations (but *Zostera* is an exception to this rule). Burrowing animals and rooted plants are characteristic of this group.

The following table gives a classification of formations in the littoral belt. Definitions of each formation and descriptions of typical associations are given in the next section.

TABLE OF PRINCIPAL MARINE LITTORAL FORMATIONS IN NEW ZEALAND.

Formations.	Associations.
	Group I.—Formations on Rock.
	Series 1.—Algae.
Large brown algae	*Durvillea antarctica ; Carpophyllum-Lessonia.*
Small emerging algae—	
Subformation 1 ..	*Corallina ; Corallina-Hormosira.*
Subformation 2 ..	*Hormosira Banksii.*
Subformation 3 ..	*Porphyra columbina ; Ulva rigida.*
Subformation 4 ..	*Bostrychia arbuscula ; Caulacanthus spinellus.*
	Series 2.—Benthic Animals.
Coriaceous-coated animals ..	*Cynthia ; Corella.*
Shelled animals—	
Subformation 1 ..	*Mytilus ; Ostrea cucullata ; Modiolus pulex.*
Subformation 2 ..	*Vermilia carinifera.*
Subformation 3 ..	*Elminius plicatus ; Chamaesipho columna.*
Subformation 4 ..	*Cellana-Monodonta ; Melaraphe.*
	Group II.—Formations on Sand and Mud.
	Series 3.—Benthic (Burrowing) Animals.
Burrowing mollusca ..	*Amphidesma ; Antigona stutchburyi ; Phytia.*
	Series 4.—Herbaceous Plants.
Grass-wrack	*Zostera.*
Salt-reed-swamp	*Juncus-Leptocarpus.*
	Series 5.—Mangrove.
Mangrove	*Avincennia officinalis.*

LARGE-BROWN-ALGAE FORMATION.

The habitat of the large-brown-algae formation consists of rocks about and below low-tide mark. At low water, spring tides, the formation may be exposed for half a metre in vertical width ; at neap tides it will not be uncovered. Moderate waves wash to the upper limit during low water, spring tides, so that the formation is almost constantly wet. It occurs on all rocky coasts, entering harbours until the influence of fresh water is felt. It is better developed in the south than in the north. The dominant growth-form is a large brown alga, usually fixed by a discoidal holdfast. The algae grow close together, forming a continuous covering. Epiphytes consist of algae and animals. There is an undergrowth of small algae, chiefly coralline and soft red kinds, while the rock-surface may be covered with *Melobesia* and *Lithothamnion.*

The large brown algae have tough pliant stems and usually narrow segments, either ribbon-like or leaf-like, and are buoyed up by vesicles or large air-cells. There is an outer layer of very dense tissue consisting of small cells with thick walls and filled with brown granules. This passes into a central colourless large-celled tissue. The thallus-segments are

always isolateral. Two or more distinct associations are to be recognized: *Durvillea antarctica* is dominant in an association characteristic of the south, whilst *Carpophyllum maschalocarpum* is the principal species in an association extending throughout New Zealand. Where there is a level rocky bottom above the *Durvillea* association a *Xiphophora* association may be developed.

The large-brown-algae formation appears to be best represented in temperate seas. In Tasmania and the southern coasts of Australia *Durvillea potatorum* is dominant in an association comparable with that of *Durvillea antarctica* in New Zealand. Outside New Zealand, *D. antarctica* is recorded from Kerguelen, South Georgia, and the Falkland Islands. An association described by Hedley from New South Wales (1915, p. 59) has *Eclonia radiata* and *Sargassum tristichum* as leading species, and is externally similar to the association in Hauraki Gulf, where *Eclonia Richardsoni* and *Carpophyllum maschalocarpum* take their place. In the North Atlantic these are represented by *Laminaria digitata* and *Fucus vesiculosus* (Cotton, Transeau). In warmer waters the principal algae are smaller and the species fewer. In Queensland species of *Sargassum* are dominant (Johnston. 1917, p. 55); in Tahiti the outside reef supports a low growth of *Sargassum* and *Turbinaria.*

Durvillea Association.

This association is characterized by the presence of the large kelp *Durvillea antarctica.* This alga stands out above the others like a lofty tree in a forest, forming a tier of vegetation by itself. Below is a growth of *Marginaria*, *Lessonia*, and other algae equivalent in size and appearance to those dominant in the *Carpophyllum* association, where *Durvillea* is absent. *Durvillea* is thus like an extra form imposed on an association of smaller algae, but it may become so dense as to displace many of the smaller kinds. *Durvillea* always grows in exposed places, and appears to be confined to the surf belt, not extending into deep water. It assumes two forms, one with broad thalli, the other with long narrow segments, this latter form occurring in places exposed to tidal currents. A characteristic fauna is found in cavities hollowed out of the large holdfasts of *Durvillea.*

Durvillea has a tough outer layer of twenty or thirty rows of oblong cells placed with their longer axes at right angles to the surface, as in palisade tissue. These cells have thick walls, and are filled with brown granules, which are most dense along the outer edge. Beneath this follows a layer, twice as thick as the palisade layer, of interwoven branched nucleated septate threads, similar in appearance to fungal hyphae. Some of this tissue consists of a mixture of filiform and isodiametric cells. The central tissue is composed of a single layer of very large columnar polygonal cells stretching across at right angles to the lamina. (Fig. 3.)

The *Durvillea* association is well developed in the south of New Zealand, extending as far north as Cook Strait on the east and to north of Manukau Heads (Te Henga) on the west. It occurs also at the Chatham Islands. The species is recorded elsewhere in the New Zealand area from the Snares, Auckland, and Campbell Islands.

Shag Point.—Along the outer margin of rocks about low-water mark there occurs a regular marine forest of the large kelp *Durvillea antarctica.* This species forms the most conspicuous feature of the tidal rocks when the water is low, but it merely dominates a much denser growth of other large brown algae. The *Durvillea* plants are attached to the rocks by broad disc-like holdfasts, usually fixed in elevated positions. From the holdfast

springs a solid trunk, which presently expands into a large flabellate thallus with many various-sized segments. These sweep about in the waves, and are usually broken off at the ends. *Durvillea* fronds are fairly buoyant, as the bulk of the tissue is made up of long polygonal cells stretching across the lamina and terminating in tough cortical tissue of small cells. They frequently support large colonies of the epiphyte *Porphyra subtumens*. The main tier of vegetation in this association is composed of *Macrocystis pyrifera* and *Marginaria boryana* in deeper water, but farthest inshore *Cystophora retroflexa* and *Xiphophora chondophylla* are dominant.

The *Cystophora* grows fairly closely, and reaches a length of 30 cm. to 50 cm. It bears along its entire length an abundance of epiphytes, consisting chiefly of large clusters of *Corallina*. Other epiphytes are various red algae. As usual in the large-brown-algae formation, *Xiphophora chondrophylla* is most abundant along the upper edge. Occurring with it are *Chaetomorpha Darwinii* and other algae, chiefly red kinds.

The undergrowth of this association consists mainly of red algae, of which there are a number of species. Encrusting the rock-surface is *Melobesia*, while there is a carpet 8 cm. to 10 cm. tall of *Amphiroa* and *Corallina*. The molluscs *Plaxiphora biramosa*, *Patelloidea stella corticata*, and *Astraea sulcata*, occurring on the rocks, almost invariably have their shells covered with *Melobesia*.

The under-sides of the holdfasts of *Durvillea* are the favourite resorts of a varied assemblage of animals, which collect there, some apparently for feeding on the *Durvillea*, others perhaps for prey, and others again for shelter from the surf while the tide is up, and from the sun while the tide is down. The holdfasts of *Durvillea* are broad disc-like bases, more or less circular in outline, from 20 cm. to 30 cm. in diameter or more, and about 10 cm. high in the centre. They are composed of solid firm tissue, which is added to by growth on the outside. But for this growth the *Durvillea* would not hold its own against the depredations of herbivorous gasteropods; for these bore their way in, hollow out the central part, and so make quite a spacious shelter with several exits. The floor of this chamber is the rock-surface, the roof the irregular surface of the *Durvillea*. The roof is arched and hollowed out into a number of concavities of different depths, caused by the ravages of the following molluscs—*Onithochiton neglectus*, *Plaxiphora egregia*, *Margarella antipoda*, *Cantharidus oliveri*, *Siphonaria australis*, and *Cantharidella nitida*—which eat hollows for themselves. The foot in the case of *Onithochiton*, *Plaxiphora*, and *Siphonaria* is protruded into the concavity well outside the limits of the shell. With the molluscs mentioned are associated numbers of *Sphaeroma*, brown sea-anemones, *Nereis magalhaensis*, *Lumbriconereis sphaerocephala*, and *Spirorbis* on the shells of *Siphonaria* and *Margarella*.

On the rock-surface under the *Durvillea* base a slightly different set of animals is found. The following are commonly met with here: *Sypharochiton sinclairi*, *Euthria linea*, *Petrolisthes elongatus*, *Halicarcinus planatus*, *Thoristella oppressus*, *Haliotis australis*, sponges, tunicates, shrimps, worms, and *Trachelochismus pinnulatus*.

Cook Strait.—The *Durvillea* association here differs from that at Shag Point in a few particulars. At Lyall Bay the large-brown-algae formation extends from low-water level, neap tides, down as far as can be seen from the rocks. But the *Durvillea* association appears to be confined to the surf zone. Looking into deep water, one sees only *Lessonia*, *Carpophyllum*, and other algae of similar size. The holdfasts of *Durvillea* are usually fixed

along the upper level of the association. This alga grows so thickly that its wide thalli when lying on the rocks cover up entirely all the other vegetation. The holdfasts here are small compared to those found farther south, and the life they shelter is not so varied. Which species first bore into them I am unable to say, but *Siphonaria australis* is an early visitor. Other species found in the holdfast-cavities are *Onithochiton neglectus*, *Plaxiphora egregia*, *Sypharochiton sinclairi*, and *Sphaeroma*.

Along the upper margin of the *Durvillea* association there is a belt of *Xiphophora chondrophylla*. Lower down larger brown algae occur: they are principally *Marginaria Boryana*, *Lessonia variegata*, *Carpophyllum maschalocarpum*, and *Cystophora dumosa*. Beneath these the rock-surface is completely covered with corallines—*Amphiroa*, *Corallina*, *Melobesia*—and a number of small red and brown algae, such as *Pterocladia lucida*, *Zonaria Turneriana*, *Glossophora Harveyi*, and *Stypocaulon paniculatum*.

Animals found on the rocks in this association include *Patelloidea stella corticata* (abundant and always covered with *Melobesia*), *Haliotis iris*, *H. australis*, *Siphonaria zealandica*, *Sypharochiton sinclairi*, *Patiriella regularis*, and a few tunicates. On the fronds of *Lessonia* occur *Cantharidus opalus* and *C. purpuratus*. (Plate 43, fig. 2.)

Te Henga.—This locality, north of Manukau Heads, is near the northern limit of *Durvillea antarctica*. The kelp here grows in a belt on the rocks, extending to about 1 m. above low-tide mark, and exposed to the full fury of the westerly seas. Where it is fairly dense its long thalli hang down and entirely hide the rock-face from view. The rock is covered with *Melobesia*, while scattered over it fairly thickly are some brown and red algae.

There are few molluscs on the rocks. *Sypharochiton sinclairi* is common; *Plaxiphora obtecta*, with clean non-eroded shells, is found here and there; and *P. caelata* also occurs. A single small specimen of *P. biramosa* was found. A large starfish, *Stichaster australis*, is extremely common and very conspicuous: it varies in colour from red to purple. Underneath the holdfasts of *Durvillea* is *Venerupis reflexa*.

Carpophyllum Association.

This association is found from the North Cape to Stewart Island. *Carpophyllum maschalocarpum*, the dominant plant, has small elliptic thallus-segments, 2–3 cm. long and ½–1 cm. wide. There is an outer row of cells about five times as long as wide, with the long axes at right angles to the surface, and brown granules at the inner end. Following this is a dense tissue, thicker near the middle of the thallus-segment than near the margins, of cubical cells with thick walls and containing brown granules. The central tissue is composed of quite large cells; those next the tough cortex just described are polygonal, those in the centre elongated and forming denser tissue. (Fig. 6.)

Rangitoto.—At the Beacon Reef, on the north-west side of Rangitoto, a large-brown-algae formation is well developed. On rocks exposed only at spring tides and extending below low-tide mark for a little distance there is a dense growth, 20–30 cm. tall, composed mainly of four species of brown algae. *Carpophyllum maschalocarpum* and *C. plumosum* are perhaps dominant over most of the area; *Xiphophora chondrophylla* is most abundant along the upper margin, and *Eclonia Richardsonia* in the lower portion. *Sargassum Sinclairii* and *Cystophora dumosa* are also fairly common. On the brown algae are found plentifully *Trochus viridis*, *T. tiaratus*, and *Cantharidus dilatatus*, all herbivorous gasteropods having

shells without siphons. There is an undergrowth of small algae, including *Pterocladia lucida*, *Melanthalia abscissa*, and, in open places, *Caulerpa sedoides*. Several small fishes were caught in the brown algae: those identified were *Ichthyocampus filum*, *Ericentrus rubrus*, and *Notoclinus fenestratus*.

Tunicates are not generally found on the upper surface of the rocks, but under overhanging projections. *Styela caerulea* and other forms, as well as the sponge *Tethya*, occur in such situations. The starfishes *Patiriella regularis* and *Stegnaster inflatus* are inhabitants of this association; also the gasteropod *Crepidula crepidula*, within the aperture of disused shells of *Verconella*. Under stones occur a wealth of life, but no algae. Of the following species some (pelecypods, *Ophiopteris*, *Callochiton*, *Macandrellus*, *Calyptrea*, *Euchelus*) are permanent residents; the rest wander farther afield when covered by the tide—*Euthria linea*, *E. vittata*, *Cominella virgata*, *Verconella adusta*, *Euchellus bellus*, *Tugalia intermedia*, *Chlamys zealandiae*, *Monia zelandica*, *Saxicava arctica*, *Calpytrea tenuis*, *Crepidula costata*, *Callochiton platessa*, *Macandrellus violaceus*, *Cryptoconchus porosus*, *Ophiopteris antipoda*.

Tauranga.—On rocks at low-water mark along the northern base of Mount Maunganui there exists a well-defined belt of large brown algae 30 cm. to 60 cm. tall. The upper limit is composed of a strip of *Xiphophora chondrophylla*, and is sharply marked off from the next succeeding belt of *Corallina*. Below the *Xiphophora* and mixing with it is *Carpophyllum maschalocarpum*, the dominant species of the association. With it occurs *Lessonia variegata*. As undergrowth to these brown algae occur many smaller kinds, especially red algae, among which *Melanthalia abscissa* and *Pterocladia lucida* are prominent. On the rock-surface *Sypharochiton sinclairi* is common; *Onithochiton neglectus* less so. The shells of *Turbo smaragdus* are usually covered with a brown crustaceous alga, *Leathesia*, and they may also support *Crepidula costata*. Large animals included in this association, besides *Turbo*, are *Neothais succincta*, *Evechinus chloroticus*, *Patiriella regularis*, and *Stichaster australis*.

On the algae are numerous smaller animals. Young *Mytilus canaliculatus* under 10 mm. in length were found abundantly attached to the thalli of *Carpophyllum*; but their instinct here appeared to be at fault, unless they were able afterwards to detach themselves and settle on rock. The herbivorous gasteropods *Cantharidus purpuratus* and *Cantharidella nitida* are common on *Carpophyllum*. The red algae *Melanthalia* and *Pterocladia* are particularly rich in epiphytic life. Encrusting the main stems are polyzoa and *Lithothamnion*, while the branches of these algae are swarming with small red amphipods and isopods—*Scutuloidea maculata*, *Hyale rubra*, *Podocerus cristatus*, and *Dynamenella huttoni*.

Cook Strait.—At Lyall Bay there is a very rich development of the large-brown-algae formation from low-water level, neap tides, down as far as can be seen. The dominant plants are *Carpophyllum maschalocarpum* and *Lessonia variegata*. These together with *Cystophora dumosa* and *Marginaria Boryana* form a growth ½ m. to 1 m. tall, almost completely covering the rocks. Along the upper margin *Xiphophora chondrophylla* is dominant in a narrow belt. There are a number of epiphytes, though they are not conspicuous, and everywhere at low tide is a luxuriant undergrowth. This consists, in the first place, of various species of *Corallina*, *Amphiroa*, and *Melobesia*, covering the rock-surface, and, secondly, of a number of algae, 10 cm. to 20 cm. tall—*Melanthalia abscissa*, *Pterocladia*

lucida, *Zonaria Turneriana*, *Caulerpa sedoides*, *Stypocaulon paniculatum*, *Glossophora Harveyi*, and others.

A number of molluscs and other animals are found in this association. In most cases the molluscan shells are covered with *Melobesia*. Common species are *Haliotis iris*, *H. australis*, *Turbo smaragdus*, *Patelloida stella corticata*, *Sypharochiton sinclairi*, *Cantharidus oliveri*, *Stichaster australis*, and *Asterias scabra*. Less abundant are *Cellana stellifera*, *Radiacmea rubiginosa*, *Plaxiphora biramosa*, and *Neothais succincta*. *Eupagurus novae-zealandiae*, in company with *Crepidula crepidula*, inhabits disused gasteropod shells.

Xiphophora Association.

A *Xiphophora* association may occur where there are small level stretches of rock about low-tide mark. *Xiphophora chondrophylla* possesses no air-vesicles, but the central tissue (medulla) is composed of large cells, which doubtless render it a little buoyant. The cortex is dense, and consists of small cells with fairly thick walls, and filled with brown granules. These increase in size after about the fourth row. In the medulla are three kinds of cells—isodiametric; cells joined in pairs with the plastids collected at the ends and the cells thin at the point of junction, thus looking like dumb-bells; long septate cells like fungal hypae. (Fig. 5.)

Otago Peninsula.—Inshore of the *Durvillea* association at Maori Papanui Bay, *Xiphophora chondrophylla* occupies a belt in which are mixed a few plants of *Lessonia variegata* and *Pachymenia lusoria*. Besides the *Xiphophora*, clusters of *Mytilus canaliculatus* are the most conspicuous feature of this association. Here and there *Boltenia pachydermatina* rears its head to a level with the brown algae. Underneath the *Xiphophora*, however, is a rich and varied assemblage of organisms. The lower parts of the stems of the algae and *Boltenia* support *Sertularia* and polyzoa. There is an undergrowth of red algae, branching polyzoa, sponges, and *Codium adhaerens*. The animals include *Cellana radians* covered with *Melobesia*, *Calliostoma punctulatum*, *Cryptoconchus porosus*, *Patiriella*, *regularis*, *Monodonta coracina*, *Paramithrax*, and *Diplocrepis puniceus*. Under stones many more kinds occur—*Ophionereis schayeri*, *Onithochiton neglectus*, *Euthria linea*, hermit and other crabs, worms and other invertebrates.

SMALL-EMERGING-ALGAE FORMATION.

This formation is found on rocks in the mid-tide belt. Most of the associations are fairly tolerant of some little admixture of fresh water, and also appear to delight in turbid water, as they gather muddy sediment in quantities. This may help to conserve moisture during exposure by the tide. The dominant growth-forms are small algae, associated with which are fixed and free shelled animals. Only one stratum of life is thus to be distinguished. The essential difference between the small emerging algae and the large brown kinds is that the former are able to remain exposed to the atmosphere for a considerable portion of each day. The adaptations to this end are various. *Hormosira* contains internal reservoirs of water; *Splachnidium* contains watery jelly, and has besides, over a tough cortex, a coating of slime. *Bostrychia* and *Caulacanthus* possess outer tissue of small thick-walled cells; *Porphyra* and *Ulva* are covered with a thin film of gummy matter which gives a glistening effect on the dried thallus. Structures concerned in the conservation of moisture in

Corallina are not so obvious. The deposit of carbonate of lime may be of some use in this respect, but of this there appears to be no evidence.

Four subformations based on the dominant growth-form may be distinguished—namely, coralline algae, small brown algae, ulvoid algae, and small olive-red algae. *Corallina* is dominant on exposed rocks above the brown-algae formation, *Hormosira* on level rocks in harbours; more usual, however, *Corallina* and *Hormosira* are fairly well mixed. *Porphyra* or *Ulva* form associations in various localities, whilst higher up on the rocks *Bostrychia* in the south and *Caulacanthus* in the north form well-defined associations.

Corallina associations appear to be found in all seas. They have been described from such widely-sundered localities as Ireland (Cotton, p. 39), New South Wales (Hedley, p. 58), and Hawaii (MacCaughey). *Porphyra* and *Ulva* associations are equally widely distributed. An association of *Hormosira Banksii* is extensively developed at Long Reef, New South Wales, and differs from similar associations in New Zealand only in the associated species of animals.

Coralline-algae Subformation.

The association in which *Corallina* is dominant is found throughout New Zealand on exposed coasts above the large-brown-algae formation, and in rock-pools between tide-marks. It forms a low growth of little tufts, which collect quantities of sediment, especially in sheltered situations. The most common association of algae in the mid-tide belt in New Zealand is that of *Corallina* and *Hormosira*. *Corallina* appears to require more water than *Hormosira*, being always found in wetter situations. Also, while *Corallina* is found exposed to the strongest surf, *Hormosira* is never found in such places. The *Corallina-Hormosira* association is best developed in harbours. Both plants are tolerant of a certain admixture of fresh water, and of mud with the sea-water. Associated with these algae are always a number of shelled animals—molluscs, worms, sessile barnacles.

Corallina Association.

Tauranga.—Immediately above the brown-algae formation on the North Rocks, Mount Maunganui, there is a belt more or less covered with *Corallina officinalis* and other small algae. There is also a good deal of *Elminius modestus*, and in crevices *Vermilia carinifera*. On the rocks are many molluscs—*Cellana radians*, *Sypharochiton pellisserpentis*, *Lepsiella scobina*; also the starfish *Patiriella regularis*.

Auckland Harbour.—In pools on the reef stretching towards Kauri Point the rocky bottom is covered with *Corallina officinalis* mixed with *Colpomenia sinuosa* and other small algae. There are a few sponges, while *Turbo smaragdus* and *Cerithidea subcarinata* are abundant. Small examples of *Amaurochiton glaucus* occur on the shells of *Turbo*, whilst *Dardanula olivacea* swarm among the *Corallina*.

Corallina-Hormosira Association.

Takapuna.—Here are extensive areas of volcanic rocks covered with a *Corallina-Hormosira* association fairly uniform in composition. *Corallina officinalis* affects wetter situations than *Hormosira Banksii*, so that in shallow pools one finds that *Corallina* covers the bottom while *Hormosira* occurs as a fringe round the edge, and on rough surfaces *Hormosira* is found

on the projections and in the hollows. In the lower portion of the association occur *Scytothamnus australis*, *Colpomenia sinuosa*, and, in shady places, *Codium adhaerens*. *Cerithidea subcarinata* is abundant on the *Corallina*, especially in rock-pools. The principal mollusc, however, is *Turbo smaragdus*, which occurs plentifully on algae throughout the whole association. It has attached to its shell small *Elminius modestus* and *Crepidula crepidula*. Other molluscs are *Haustrum haustrum*, *Neothais succincta*, *Cominella maculosa*, *Lepsiella scobina*, and *Sypharochiton pellisserpentis*. (Plate 44, fig. 1.)

Bay of Islands.—At Long Beach this association is developed on rocks above the brown-algae formation and below the *Ostrea* association. *Hormosira Banksii* is plentiful, especially in crevices and small pools. Mixed with it is *Colpomenia sinuosa*, and a few plants of *Xiphophora chondrophylla*. *Corallina officinalis* covers the bottom of rock-pools. On rocks round the edges of crevices containing water is *Caulacanthus spinellus*. The rock-surface is almost completely covered with a veneer of *Elminius modestus*. Common everywhere, chiefly in crevices during exposure by the tide, are *Turbo smaragdus* (on algae), *Sypharochiton pellisserpentis* with much-eroded valves, *Vermilia carinifera* (sometimes forming patches), *Nerita melanotragus*, *Lepsiella scobina* with eroded shells carrying small *Elminius*, *Cellana radians*, *Elminius plicatus*, and a few *Anomia walteri* with thick eroded shells bearing *Spirorbis*.

Shag Point.—Between tide-marks at Shag Point are some fairly wide stretches of nearly level rocks. Just within the outer edge with its formation of brown algae there are regular meadows of small algae 4 cm. to 5 cm. tall. Generally the rocks are completely covered, and the association differs according to exposure. Over most of the area the dominant species are *Corallina officinalis* and *Hormosira Banksii*; but many other species occur, all, however, of low growth. Standing out among the close growth are *Colpomenia sinuosa* and *Adenocystis utricularis*, both possessing hollow thalli, generally full of water. In crevices are found larger algae, such as *Cystophora dumosa*.

Most conspicuous among the mollusca in this association is *Turbo smaragdus*, which occurs abundantly throughout, and supports on its shell the crustaceous brown algae *Leathesia*. A few *Turbo granosus* may be seen; also present are *Cantharidus tenebrosus* and *Monodonta aethiops*. Occurring in the algae are the small pelecypods *Lasaea miliaris* and *Verticipronus mytilus*, and the amphipod *Hyale hirtipalma*; also the worms *Nereis vaucaurica*, *Onuphis tubicola*, and *Lumbriconereis spherocephala*. Where there are bare spaces on the rocks *Patelloidea stella corticata* covered with *Melobesia*, *Cellana radians*, and *Sypharochiton pellisserpentis* will be found.

Towards low-water mark *Hormosira* is not found, and *Corallina officinalis* is no longer dominant. Instead is a thick low growth of *Stypocaulon*, *Ballia*, *Nitophyllum*, numerous corallines, red weeds, and *Chaetomorpha*. Mollusca occur on the rock-surface under the algae. In such situations are *Cellana radians*, *Plaxiphora caelata*, *Sypharochiton sinclairi*, and *Acanthochiton zealandicus*. (Plate 44, fig. 2.)

Small-brown-algae Subformation.

Hormosira Banksii, when dominant, usually forms a nearly pure association, as far as algae are concerned, on level rocks between tides in harbours. Such an association is well developed at Waitangi, Chatham Island, and near Purau, in Lyttelton Harbour. *Hormosira* can endure long exposure

to the atmosphere, being enabled to do so by a large quantity of water contained in the hollow and distended internodes. The influence of fresh or turbid water seems not in the least harmful to this alga. There is a cortex of four or five rows of rectangular cells arranged like palisade tissue and filled with brown granules. Beneath this are the large polygonal cells of the medulla, the outer ones of which have brown granules. Inside this to the central water-chamber are straight septate filaments.

Chatham Island.—The sea-water in Waitangi Bay is very much discoloured by the peaty water discharged by the Waitangi River. The rocks are soft brown sandstones shelving between tide-marks. Above the large-brown-algae formation there is a considerable area covered with *Hormosira Banksii.* This alga grows very thickly, completely covering the rocks. Underneath there is little life, only *Monodonta coracina* and *Sypharochiton pellisserpentis* being seen ; but on the rock where *Hormosira* is more open there are numerous gasteropods. *Cerithidea subcarinata* is abundant ; also common are *Cominella maculosa, Haustrum haustrum, Monodonta aethiops*, and (especially near the upper margin of the belt) *Melaraphe unifasciata, M. cincta, Siphonaria zealandica*, and *Cellana strigilis.* (Plate 45, fig. 1.)

Ulvoid-algae Subformation.

Two associations are here included : one consists of *Porphyra columbina*, on rocks about half-tide mark ; the other of *Ulva rigida*, often in situations subject to the influence of fresh water. Both these species, though having broad, delicate thalli, are able to remain for a considerable period exposed to the atmosphere. *Porphyra* under these circumstances shows signs of wilting. On drying, both species have a glistening appearance, due to a thin coating of mucilaginous matter, which probably assists in preventing excessive transpiration.

Ulva Association.

Rangitoto.—On the north coast of Rangitoto is a small pool separated from the sea by a shingle-bank. Into this the sea must penetrate, for it contains brackish water and an association of marine organisms. There is a thick growth of *Ulva rigida.* The animals include *Sypharochiton pellisserpentis, Monodonta aethiops*, and some sea-anemones, all of which are abundant. Less common are *Acanthochiton zealandicus, Lepsiella scobina, Cerithidea subcarinata*, and *Patiriella regularis.* The *Acanthochiton* and *Patiriella* are whitish, and all the other shells are more or less eroded.

Porphyra Association.

Cook Strait.—At Lyall Bay there is a well-marked association of *Porphyra columbina*, which occurs in patches, especially covering rocky platforms not far above the level of half-tide. In many places it grows so thickly that it entirely hides from view areas of rock 2 m. or 3 m. across. Exposed to the air, the thallus lies flat on the rocks. When dried it has a glistening appearance, due to a coating of mucilage. The tips are frayed, as if suffering from wilting during too severe drying conditions. The colour is very varied, owing to different degrees of exposure. The base, which gets most protection, is dark green or brownish-green ; exposed parts are reddish or pale green. Associated algae are a few plants of *Ulva* and some small filamentous red kinds.

The animals occurring with *Porphyra* are those of the *Chamaesipho* association, which occupies most of the mid-tide belt hereabouts. They

include *Chamaesipho columna*, *Elminius plicatus*, *Cellana ornata*, *C. denticulata*, *Siphonaria obliquata*, *S. zealandica*, *Risellopsis varia*, and *Melaraphe cincta*; also *Sypharochiton pellisserpentis* in crevices, and *Melaraphe unifasciata* in the upper portion of the association.

Small-olive-red-algae Subformation.

Two associations of small close-growing algae are included. The *Bostrychia* association occurs high up in the intertidal belt, where it occupies patches of various sizes on the rocks. It always harbours small pelecypods and gasteropods. *Bostrychia arbuscula* has an outside layer of tissue with thick-walled polygonal cells. Under drying conditions of the atmosphere it shows signs of wilting, the tips of the filiform thallus-segments curling up. This association is confined to the south of New Zealand. I have not observed it farther north than Shag Point, Otago.

Caulacanthus spinellus is more widely distributed, and is the northern representative of the small-olive-red-algae subformation. It occupies patches of rock above the belt of *Ostrea cucullata*, usually affecting shady places. It is of low, dense growth, and harbours small pelecypods, worms, and other animals.

Bostrychia Association.

Stewart Island.—The upper belt of intertidal rocks at Golden Bay is characterized by an association in which *Bostrychia arbuscula* takes the chief part. This species covers patches of the rock to a height of about 20 mm., growing in little tufts. The belt it occupies would be exposed to the atmosphere for more than twelve hours daily. The tips of the thalli are filiform, and curl up in the sunshine and wind. At the base of this alga is found abundantly the small pelecypod *Lasaea miliaris* and small amphipods. Also characteristic of this association are *Melaraphe cincta*, some small *Elminius modestus*, *Risellopsis varia*, *Notoacmea parviconoidea*, and *Modiolus pulex*. Under stones one finds *Atalacmea unguis-almae*, *Leuconopsis obsoleta*, and small *Monodonta coracina*.

St. Clair.—On rocks near high-water mark there is a well-marked belt composed of a close growth, 1–2 cm. tall, of *Bostrychia arbuscula*. The plant alters very little in appearance when left by the tide, though it may be exposed for eighteen hours a day. *Bostrychia arbuscula* forms large patches, it being the only alga found here in any quantity near the top of the tidal belt. Its base collects a little sand, and here is found *Lasaea miliaris*, and small examples of *Modiolus pulex* and *Elminius modestus*. Crawling over the *Bostrychia* are large numbers of young *Melaraphe cincta*, with black, shining, depressed shells up to 5 mm. long. Other molluscs occurring in this association are the young of *Lepsiella scobina* and *Siphonaria zealandica*.

Shag Point.—Here this association is developed in patches above half-tide mark. There is a fairly dense growth of *Bostrychia arbuscula*, 1–1·5 cm. tall. The bases of the thalli are flat, give off branches on each side, and at the ends clusters of filaments 0·1 mm. in diameter. On the rock-surface are small specimens of *Chamaesipho columna* and *Modiolus pulex*. The alga grows on these as well as on the rock. Among the bases of *Bostrychia* are crowds of *Lasaea miliaris*, 2–3 mm. in length. These shells contain young up to 0·6 mm. long. Young shells of *Melaraphe cincta* up to 6 mm. are abundant, all shells from 2 mm. to 3 mm. and longer having the spire eroded. The young of *Risellopsis varia* are not common, but occur up

to 3 mm. in diameter. Adult shells of *Melaraphe* and *Risellopsis* are not found in this association, but occur at higher levels Two crustacea are found among *Bostrychia*—a small Sphaeroma and a small orchestid. (Plate 46, fig. 1.)

Caulacanthus Association. (Plate 43, fig. 1.)

North Head, Auckland.—The rocks here are a volcanic breccia, rough with projecting fragments. The association in which *Caulacanthus spinellus* is dominant occupies a belt above the *Ostrea* and below the *Chamaesipho* associations. *Caulacanthus* occurs in irregular patches 2–3 cm. to 50 cm. in diameter and 10–15 mm. high. It is reddish-olive, but in bright sunlight shows a light olive colour. Its dense mats keep moist between tides, and harbour a quantity of mud. In places it is mixed with the pelecypod *Modiolus pulex*. On its surface are found many *Onchidella* and a few *Lepsiella scobina*; but underneath is a much greater variety of life—*Nereis amblyodonta*, *Onchidella*, *Sypharochiton pellisserpentis*, *Lasaea miliaris*, *Plaxiphora caelata*, sipunculids, spiders, and *Risellopsis varia*.

The *Caulacanthus* association does not form a continuous covering in the belt in which it occurs. The greater portion of the rock-surface is occupied by a nearly uniform covering of small *Elminius modestus*, with which are associated *Elminius plicatus*, *Chamaesipho columna*, *Sypharochiton pellisserpentis*, and various gasteropods—*Lepsiella scobina*, *Nerita melanotragus*, *Monodonta aethiops*, *Siphonaria zealandica*, *Risellopsis varia*, and *Turbo smaragdus*.

Coriaceous-coated-animals Formation.

On rocks near low-tide mark in a few localities in New Zealand there are associations in which a tunicate is dominant. The tunicate may occur in clusters, or closely packed in a single layer, and occupies the rocks to a height of 5 cm. or 6 cm. On the tests are usually small algae, among the clusters crabs and molluscs, while underneath may be a great variety of animal life or, if the tunicates are close-growing, only a few forms. Tunicates are furnished with very tough tests, and are able without harm for a considerable portion of each day to remain exposed to the atmosphere. There are only two apertures in the test, both small, and capable of being closed by the animal at will. Though one or two species of tunicates occur sparingly up to about half-tide level, those which form close associations are found only near low-tide mark.

I have notes of three associations in New Zealand—one at Spirits Bay, on rocks exposed to the surf; one in Auckland Harbour, in water frequently turbid; and a third under stones in various localities. I have not been able to ascertain the names of the species of tunicates dominant in the following associations. In Australia and Tasmania *Cynthia praeputialis* forms an association on exposed coasts.

Cynthia Association.

Auckland Harbour.—A long reef of volcanic rocks stretches from west of Ponsonby towards Kauri Point, fairly across the tidal currents. Rivers flowing into the upper reaches of the harbour bring down much mud and decayed vegetable matter, a great deal of this being caught by the reef, which, except where exposed to the scouring action of waves and tides, bears a coating of slimy mud. It is not to be wondered at, therefore, that animal associations rich in individuals and species are found near low-tide

FIG. 1.—Upper surface of a rock, looking east, Takapuna. On the north (left) side is *Chamaesipho columna;* on the south (right) side *Caulacanthus spinellus Ostrea cucullata* on detached rock.

FIG. 2.—*Durvillea antarctica* association, low-tide belt, Island Bay, Cook Strait.

FIG. 1.—*Corallina-Hormosira* association with *Turbo smaragdus*, Takapuna.

FIG. 2.—*Corallina-Hormosira* association with *Turbo smaragdus*, Shag Point. *Durvillea antarctica* along seaward edge.

FIG. 1.—*Hormosira Banksii* association, Waitangi, Chatham Islands.

FIG. 2.—Mid-tide belt, Taylor's Mistake. On left, *Mytilus planulatus*; on right, *Vermilia carinifera*.

Fig. 1.—Mid-tide belt, Shag Point. Above is the alga *Bostrychia arbuscula*; below, the barnacle *Elminius plicatus*.

Fig. 2.—*Ostrea cucullata*, Takapuna.

mark near the outer extremity of this reef. Two such communities are very conspicuous: one is that of *Vermilia carinifera*, quite the most remarkable of its kind I have seen; the other is an association in which the tunicate *Cynthia* is the dominant form. This species occupies a belt of rocks extending from low-water mark at spring tides to nearly 1 m. in vertical height above. It occurs usually in clusters, some twenty or thirty being united, and attached to the rock or to an adjoining cluster at five or six places only. The depth of the covering thus formed is about 5 cm. (Plate 42, fig. 3.) The tunicate does not completely cover the rock, but occurs in patches 10 cm. to 20 cm. in diameter. The angles of the rocks are preferred, and small irregular rocks are quite covered, but the smooth rocks are usually more or less bare. The fact that the individuals in a cluster can be separated, though with difficulty, shows that the mode of forming clusters is simply by the young settling on the outside of the tests of older individuals and growing there. Many young can be found in such positions. The tests, where touching, are joined together very firmly by their stringy and glutinous exteriors, and thus compact clusters are formed. Another larger species of tunicate occurs singly along the lower portion of the association.

Frequently embedded in the masses of *Cynthia* occur little colonies of *Musculus impactus*, each spinning round its shell a nest resembling a cocoon. Growing on the tunicate clusters are many plants of a small brown algae which swarms with *Rissoina olivacea*. Many gasteropods are found on and among the clusters; most common are *Euthria vittata*, *Turbo smaragdus*, *Murex octogonus*, and *Cerithidea subcarinata*, which swarms over rocks, algae, and tunicates alike. The half-crab *Petrolisthes elongatus* is extremely common, hiding among the tunicate clusters.

On rocks among the tunicates are many animals and plants. The globose sponge *Tethya*, and an encrusting bright-orange species, are common. *Corallina officinalis* is abundant, and collects a lot of mud. It appears to be the most favoured resort of *Cerithidea subcarinata*. The larger gasteropods include *Turbo smaragdus*, with fairly clean shells and eroded spire; *Cominella adspersa*, a very distinct-looking form with a pronounced shoulder beneath the suture, yellow inside, and usually extensively eroded without; *Verconella adusta*, fairly clean, though sometimes carrying a few small *Elminius*. *Ostrea corrugata* up to 7 cm. in length occurs singly or in small clusters. *Patiriella regularis* is common, and apparently always of a reddish-brown colour. *Mytilus canaliculatus* occurs singly in crevices. The shells are usually almost covered with *Crepidula crepidula*, and occasionally also some *Calyptraea novae-zealandiae*, *Amaurochiton glaucus*, and *Ischnochiton maorianus*.

The under-side of stones is equally as rich as the upper surface. Near the mud-line are *Ischnochiton maorianus* and *Lepidopleurus iredalei*; but where the water circulates freely, though light does not fall direct, there are *Cynthia*, but no algae, and numerous gasteropods, sponges, compound ascidians, sea-anemones, crabs, pelecypods, *Flabelligera lingulata*, *Nereis amblyodonta*, and other worms of various kinds. (Plate 47, fig. 1.)

Corella Association.

Bay of Islands.—On the rocky coast of Long Beach, under stones where no light penetrates, there is often a rich collection of animals. Some of these may be merely sheltering during the recess of the tide; others, on the contrary, belong to species always found attached to the under-side of

rocks. The tunicates *Corella* and *Styela caerulea* are examples. Under stones in rock-pools *Corella* is the dominant member of an association which includes many other fixed animals, such as sponges, tubicolous worms, and molluscs, polyzoa, and *Flabellum*. Chitons are plentiful: where the water is clear there will be *Macandrellus violaceus*, *Cryptoconchus porosus*, and *Onithochiton neglectus*; where it is muddy, *Amaurochiton glaucus* and *Ischnochiton maorianus*. Other characteristic animals of this association are *Haliotis iris*, *Scutus ambiguus*, *Astraea sulcata*, *Evechinus chloroticus*, *Tugalia intermedia*, and *Anomia walteri* with thin shells bearing polyzoa and *Spirorbis*. (Plate 47, fig. 2.)

Cynthia Association.

Spirits Bay.—This is the only surf tunicate formation that I have come across in New Zealand. It occupies exposed sloping rocks between tides and above the brown-algae formation. A large species of *Cynthia*, allied to *C. praeputialis* of Australia, grows closely together and completely covers the rocks to a height of 6 cm. to 8 cm. On it grows a good deal of green *Ulva*, while underneath are *Ostrea corrugata* (small, solid, 2–3 cm. long), *Philobrya costata*, *Nereis vaucaurica*, and *Calyptraea novae-zealandiae.*

Shelled-animals Formation.

This is the characteristic animal formation on rocks between tide-marks, and extends from about low-water level, neap tides, to the upper limit of marine life, which is often well above high-tide mark, and in places mixes with lichens and other terrestrial vegetation. There is but a single stratum of life—namely, a fixed or sedentary animal as a dominant member, with others, including minute forms, associated. Algae occur only sporadically As a rule, the shelled-animals formation lies above the small-algae formation, showing that shelled animals are adapted to withstand a greater degree of drying conditions than are most algae. Exceptions to this are *Bostrychia* and *Caulacanthus*, which occur well up in the intertidal belt. The essential feature of shelled animals is that they are able to keep the body in a bath of water within a calcareous shell during such time as they are exposed by the tide. This may be effected by two valves closely fitting along their edges (*Mytilus*, *Ostrea*), by the peristome of the shell being closely applied to the rock-surface (*Cellana*, *Turbo*), or by means of an operculum (*Melaraphe*, *Vermilia*) or shelly plates (*Elminius*) closing the aperture. The dominant animals are always firmly attached to the rocks by being cemented down by the base of the shell (*Elminius*), by one valve (*Ostrea*), or the whole length of the shell (*Vermilia*); or they may be attached by means of a byssus passing through a narrow opening between the valves (*Mytilus*). There are associations in which the dominant animals are not fixed (*Cellana - Monodonta*, *Melaraphe*). Lastly, the dominant animal feeds on minute organisms contained in the water (all fixed animals), or on minute forms of vegetable life (*Cellana*). Active animal- and vegetable-feeders are only subsidiary life-forms in this formation.

According to the dominant growth-form, four subformations may be distinguished, and in each of these one or more associations are recognized. The four subformations are sessile cirripede, pelecypod, tubicolous polychaet, and gasteropod.

Pelecypod Subformation.

In the northern portion of New Zealand, north of S. lat. 38°, *Ostrea cucullata* forms a conspicuous association in the mid-tide belt. It chiefly affects sheltered coasts, and sometimes covers the rock-surface to a depth of 5 cm. On the other hand, the association of *Mytilus* in the tidal belt is best developed in the southern portion of New Zealand, especially in the low-tide belt. *Modiolus*, an ally of *Mytilus*, occurs near high-tide mark throughout New Zealand.

Similar associations are represented in other temperate regions. In New South Wales (Hedley, 1915, p. 73) and in Queensland *Ostrea cucullata* is a feature of the shore as conspicuous as it is in New Zealand; but, as the animals occurring with it differ, it would form a distinct subassociation. In the Fiji Group I have noticed an association of a small species of *Ostrea*. In the British Isles *Mytilus edulis* is a dominant form, whilst representing the *Mytilus* association in New South Wales is that of *Brachyodontes hirsutus* (Hedley, p. 74), and in Tasmania *Mytilus planulatus*.

Mytilus Association.

Taylor's Mistake. — On rocks near low-tide mark there are extensive patches of *Mytilus canaliculatus* with their shells closely crowded. A large part of the surface of the shell is sometimes deeply eroded. Among the *Mytilus* are a number of brown and red algae and a little *Ulva*, whilst the rock-surface itself is covered with pink *Melobesia*. Many specimens of *Mytilus canaliculatus* contain the crab *Pinnotheres pisum*. Scattered about the rocks are several species of large molluscs and other animals—*Plaxiphora obtecta* (clean but eroded), *P. biramosa* with *Melobesia* on the valves, *Cellana radians, Stichaster suteri, Haustrum haustrum, Turbo smaragdus*, and *Plaxiphora caelata* entirely covered with a short brown alga.

Immediately above the belt of *Mytilus canaliculatus, M. planulatus* becomes the dominant species. There are here very few algae, and the mollusca and other animals differ in the main from those associated with *M. canaliculatus*. The most common species are *Elminius plicatus, E. modestus, Monodonta aethiops, Cellana radians, Sypharochiton pellis-serpentis, Vermilia carinifera* (in patches), *Brachyodontes maorianus*, and, on the valves of *M. planulatus, Notoacmea parviconoidea*. Here and there clusters of *Elminius plicatus* also occur on the valves of *Mytilus planulatus*. (Plate 45, fig. 2.)

Ostrea Association.

Takapuna.—Ostrea cucullata here occupies a well-defined belt about 1 m. in vertical width, and centred about half-tide mark. The *Ostrea* shells may be thickly scattered about, they may be in dense clusters, or the entire surface for many square metres may be covered to a depth of 6 cm. to 10 cm. The left valve is deeper than the right, and is attached to the rock by about half its area, the outer margin bending sharply up from the rock-surface as a deeply corrugated cup closed by the less concave right valve. Clusters broken off the rock are found to be composed of many shells firmly joined together. A common arrangement is for the shells to be united in pairs the edges of which partly overlap adjacent shells, thus forming a double fan. But more frequently the clusters are quite irregularly arranged.

When the *Ostrea* is dense not many other animals are associated with it. The following, however, are found in the locality here described:

Lepsiella scobina, *Nerita melanotragus*, *Turbo smaragdus*, *Sypharochiton pellisserpentis*, *Monodonta aethiops*, *Elminius plicatus*, *Cellana radians*, *C. ornatus*—all species of wide distribution in the intertidal belt throughout New Zealand. Where the *Ostrea* forms a complete covering to the rocks only small examples of these animals are found. (Plate 48, fig. 1; Plate 46, fig. 2.)

Modiolus Association.

St. Clair.—This association occupies the middle portion of the intertidal belt. The rocks are large hard lava boulders, and the patches of *Modiolus pulex* are the most conspicuous feature of the beach. The shells grow close together, the umbonal end, near which is the byssus, touching the rock, the anterior end pointing outwards. They harbour a good deal of sand, in which are found many polychaet worms. On the shells of *Modiolus* are found *Notoacmea parviconoidea*, young *Melaraphe cincta*, and *Risellopsis varia;* also here and there are bunches of *Porphyra columbina*. Pelecypods associated with *Modiolus* are a few *Mytilus planulatus* and *Brachyodontes maorianus*. On the rocks where not occupied by *Modiolus* are a number of mollusca, the following being common: *Cellana strigilis*, *C. radians*, *Siphonaria obliquata*, *S. zealandica*, *Lepsiella scobina*, *Neothais lacunosa*, *Plaxiphora caelata* (30 mm. in length and covered with small algae), and *Monodonta coracina*. In rock-pools *Modiolus* does not occur. Like many animals accustomed daily to be left dry by the tide, it seems to flourish best on rocks not constantly submerged.

Taylor's Mistake.—Near high-water mark is a well-defined belt of rocks almost entirely covered with *Modiolus pulex* and *Elminius modestus*. High neap tides cover all the animals in this association except a few *Modiolus*, *Cellana radians*, and *Monodonta aethiops*, but these are reached by the wash of every wave. Associated with the *Modiolus* and *Elminius* are *Lepsiella scobina*, *Sypharochiton pellisserpentis*, *Risellopsis varia*, *Melaraphe unifasciata*, *Cellana ornata*, *C. radians*, and *Melaraphe cincta*. *Notoacmea parviconoidea* is common on the shells of *Modiolus pulex*. All these species except *Risellopsis* and *Melaraphe* contained water within their shells, and in a specimen each of *Cellana* and *Monodonta* was found a small amphipod. At one point in the coast-line at Taylor's Mistake the variety *rutila* is freely mixed with *Lepsiella scobina*. There is no apparent difference in the habitat to cause a variation of this kind.

Modiolus confusus Association.

In brackish water *Modiolus confusus* takes the place of *M. pulex* in the tidal belt. Unfortunately I have few notes on this association. At Spirits Bay a small river runs into the sea, and is for a portion of its lower course tidal. Here in the brackish water are a few molluscs. Where there is a hard surface *Modiolus confusus* occurs in clusters. The shells are smooth, not at all eroded, and mesure up to 30 mm. in length. Common on the botton are two species of gasteropods—*Melanopsis trifasciata* and *Potamopyrgus corolla salleana*.

At Riverhead, on the Waitemata River, intertidal rocks support *Modiolus confusus* (32 mm.) and *Elminius modestus;* while at Warkworth, on the Mahurangi River, I collected *M. confusus* and *Potamopyrgus antipodum*. There appears to be a curious mixture on the western shore of the Great Lagoon on Chatham Island. Here I gathered *Modiolus confusus* (22 mm.), *Antigona stutchburyi* (small shells, 25 mm., with convex but not ventricose valves), and *Potampyrgus antipodum*.

Tubicolous-polychaet Subformation.

There appear to be several associations of this subformation, but I have notes on only one, which, however, occurs in two distinct sub-associations. (Plate 45, fig. 2, and Plate 48, fig. 2.) The association in Auckland Harbour presents little similarity to that on an exposed coast, such as on Tarakihi Rock, except that the dominant species is the same. A different association is that of a worm, *Hermella spinulosa*, forming large colonies of sand-tubes along the coast in Hauraki Gulf. In Australia the *Galeolaria caespitosa* association would belong to the present subformation (see Hedley, 1915, p. 64).

Vermilia Association.

Auckland Harbour. — This association is found chiefly on the outer portion of the reef of volcanic rocks stretching across the mud-flats from Auckland towards Kauri Point. Here in a low-lying part most of the rock is covered with mud. To the exposed pieces of the reef, and on detached rocks lying about, the colonies of *Vermilia carinifera* are attached. The *Vermilia* grows in masses, with the tubes close together and radiating outwards from the point of attachment to the rock. The apertures are all pointing outwards, and the whole mass thus formed may be 1 m. or more in length and ½ m. high. The general surface is more or less rounded, and from a distance presents very much the appearance of the vegetable sheep (*Raoulia*) of the Southern Alps.

Only the ends of the tubes are occupied, each animal being from 3 cm. to 5 cm. in length. The spaces between the tubes are filled with mud. The main portion of the mass is therefore empty tubes and mud. This association is left dry by the tide for a long time each day, and the animals, to protect themselves against desiccation, withdraw into the tubes and close the apertures by shelly opercula. (Plate 48, fig. 2.)

Tarakihi Rock, Hauraki Gulf.— *Vermilia carinifera* is here the dominant organism in a belt of rocks above the brown-algae formation. Its massed tubes form continuous coverings over large patches of rock. Associated with it is small *Chamaesipho columna*. There occur also clusters of large specimens of *Mytilus canaliculatus* (with their shells covered with *Vermilia*), *Chamaesipho*, algae, and *Crepidula crepidula*. Many of the *Mytilus* shells contain the crab *Pinnotheres pisum*. Common molluscs on the rocks are the usual intertidal species—*Neothais succincta*, *Lepsiella scobina*, *Cellana radians*, *Sypharochiton pellisserpentis*, and *Monodonta aethiops*.

Sessile-cirripede Subformation. (Plate 46, fig. 1.)

This is the most common shelled-animals community in the littoral belt. At every point on the coast some of the intertidal space is occupied by associations in which *Elminius* or *Chamaesipho* is dominant. In other temperate regions it appears to be equally well represented. In the British Isles it is *Balanus balanoides* that is dominant (Southern, p. 24); in Australia and Tasmania species of *Balanus*, *Tetraclita*, and *Catophragmus*. So far as my observations go, this formation is poorly represented in the tropics: this perhaps is due to excessive insolation.

Elminius plicatus Association.

Takapuna.—At Red Bluff, above the belt of *Ostrea cucullata*, there is a well-defined belt covered almost entirely with the large *Elminius*

plicatus. It grows in masses on all the ridges of the irregular rock-surface, avoiding little holes where water can lie; it also avoids the underside of overhanging rocks where *Ostrea cucullata*, small *Chamaesipho columna*, and *Vermilia carinifera* are found. Examining the clusters of *Elminius* closely, it is found that they appear to branch like certain corals; but in reality the branches have no organic connection with the main stem—it is merely a case of young animals settling on the shells of older ones. There may be three, four, or more generations in a cluster, and the average height of the community is between 2 cm. and 3 cm. Various small animals are found on the *Elminius* shells—*Chamaesipho columna*, *Sypharochiton pellisserpentis*, *Plaxiphora caelata*, small *Ostrea cucullata*, and *Cellana ornata;* also a small black alga. There are very few animals on the rock-surface among the *Elminius*. *Cellana ornata*, *Lepsiella scobina*, *Haustrum haustrum*, and *Sypharochiton pellisserpentis* were seen, but these are more common in shady places where *Elminius plicatus* is less abundant.

Otago Peninsula.—At Maori Papanui Bay there is an association of *Elminius plicatus* covering a wide area of rocks, here chiefly large volcanic boulders, in the mid-tide belt. Algae present are *Splachnidium rugosum* along the lower margin, and a few patches of *Bostrychia arbuscula* higher up. The rocks are to a large extent covered with *Elminius plicatus*. By young shells growing on the older ones irregular clusters are formed, and when this begins on a shell of *Mytilus planulatus* the cluster of cirripedes is frequently larger than the mussel which supports it. (Plate 42, fig. 4.) *Mytilus planulatus* occurs in large patches of closely packed shells, which, as just stated, support clusters of *Elminius plicatus*, as well as large numbers of *Notoacmea parviconoidea*, and fewer of *Lepsiella scobina*. Associated with *Elminius plicatus* on the rocks are *Cellana radians*, *Lepsiella scobina*, *Notoacmea parviconoidea*, and *Monodonta aethops*. Along the lower edge are found in addition *Mytilus canaliculatus*, *Brachyodontes maorianus*, *Sypharochiton sinclairi*, *Neothais striata*, and *Scalpellum villosum*.

Elminius modestus Association.

Stewart Island.—At Half-moon Bay, above the brown-algae formation, the rocks are sprinkled with small *Elminius modestus*, among which *Cellana strigilis*, *C. radians*, and *Monodonta aethiops* are the most conspicuous shells. The upper portion of this association contains the greatest variety of species. *Elminius modestus* is still dominant, but there also occurs plentifully a larger species, *E. plicatus;* also *Mytilus planulatus*, *Brachyodontes maorianus*, and *Cellana ornata*. Patches of *Bostrychia arbuscula* extend into this association. Other molluscs occurring on the rocks are *Sypharochiton pellisserpentis*, *Plaxiphora terminalis*, *Siphonaria zealandica*, and *Lepsiella scobina*.

A large assemblage of animals found under stones should perhaps be referred to a separate association, since, though some are animals of the *Elminius* association merely sheltering, others are permanent residents, not exposing themselves to the drying conditions of the upper surface of the rock. Besides numerous sponges, tunicates, polyzoa, and sipunculids, there are the following molluscs, echinoderms, and worms: *Euthria linea* (varying in one direction to *E. flavescens* and in another to *E. vittata*), *Neothais lacunosa squamatus*, *Monodonta lugubris*, *M. atrovirens*, *Saxicava arctica*, *Nucula nitidula*, *Paphia intermedia*, *Onithochiton negelctus*, *Patiriella regularis*, *Stichaster polyplax*, *Atalacmea unguis-almae*, *Eulalia microphylla*, *Nicolea gracilibranchis*, and *Physcosoma scolops*.

Chamaesipho Association.

Wellington Harbour.—At Worser Bay a sessile-barnacle formation occupies a belt of rocks about 1½ m. in vertical width stretching between high- and low-water levels, neap tides. Above there is nothing on the rocks save *Melaraphe;* below is a brown-algae formation. The rocks are fairly well covered with young *Chamaesipho columna.* It occurs in patches of varying extent, and is 2 mm. to 3 mm. tall. When growing close together the shells are narrow and tall, hence the columnar appearance. In the lower portion of the association a dark-brown crustaceous alga (*Leathesia*) spreads itself about the rocks among and over the *Chamaesipho.* Lower still, *Codium adhaerens* occupies considerable patches, especially on the shady sides of the rocks, while along the lower margin is a strip of *Melobesia.*

Besides *Chamaesipho,* fixed animals occur only in crevices. Here are a few specimens of *Elminius plicatus,* abundance of *Vermilia carinifera,* and many clusters of *Polinices spinosus, Mytilus planulatus,* and *Brachyodontes maorianus.* A few *Actinia tenebrosa,* a striped sea-anemone, and a brown tunicate are also found. Scattered about on the rocks among the *Chamaesipho* are a number of molluscs. Along the upper border *Notoacmea pileopsis* is common enough. Thickly scattered about throughout the association are *Risellopsis varia* and *Lepsiella scobina,* and, in the upper portion, *Melaraphe unifasciata* and *M. cincta* as well. *Cellana radians* and *Sypharochiton pellisserpentis* are abundant and conspicuous, the shells often supporting *Chamaesipho columna* and *Notoacmea parviconoidea,* and showing a considerable amount of erosion. *Monodonta aethiops* and *M. coracina* are common. They are most in evidence while covered by water, retiring to crevices and under stones as the tide ebbs. Other molluscs are *Cellana ornata, C. denticulata, Onchidella, Haustrum haustrum, Siphonaria zealandica, Turbo smaragdus* (on *Codium*), *Monodonta atrovirens,* and *M. lugubris.*

Tauranga.—On the North Rocks of Mount Maunganui, in the mid-tide belt, a sessile-barnacle formation is well developed. The lower portion of that belt immediately above the *Corallina* association is characterized by the rocks being almost entirely covered with small specimens of *Chamaesipho columna.* Associated with this species are the following molluscs, all occurring commonly: *Cellana radians, Sypharochiton pellisserpentis, Haustrum haustrum, Monodonta aethiops, M. atrovirens, Lepsiella scobina,* and *Nerita melanotragus,* all with the apex more or less eroded, in which respect *Nerita* is the most resistant. Also occurring in this association are *Elminius plicatus,* patches of *Vermilia carinifera,* and the crustaceous brown alga *Leathesia.*

In rock-pools the life is a little different. There is a certain amount of protection from the surf, and no daily exposure to the air. *Elminius* is absent, but the following animals were noticed: *Ostrea cucullata* (rare), *Turbo smaragdus, Cominella virgata, Cerithidea subcarinata, Patiriella regularis,* and *Evechinus chloroticus.*

In the upper portion of the association large specimens of *Chamaesipho columna* are the dominant forms. The shells are characterized by projecting horizontal laminae, possibly showing growth-stages. Associated with this species are *Cellana ornata, Siponaria zealandica, Notoacmea septiformis, N. parviconoidea, Patelloidea stella, Nerita melanotragus, Monodonta atrovirens, Elminius plicatus* (with *Chamaesipho columna* attached), and, especially along the upper border, *Melaraphe unifasciata.* In shady places

Notoacmea pileopsis up to 28 mm. in length and 14 mm. in height occurs. The apexes of all the shells except those of *Notoacmea pileosis* and young *Nerita melanotragus* are eroded. *N. pileopsis* shows more signs of wear than erosion. A conspicuous feature of the rocks in this association (in April) are tufts of *Porphyra columbina.*

Under stones in this belt are a few molluscs, including some not able to tolerate drying conditions of exposed rocks. *Monodonta lugubris, Sypharochiton pellisserpentis*, and *Atalacmea unguis-almae,* all with clean uneroded shells, are common. *Onchidella* is also found here.

Gasteropod Subformation.

Perhaps on account of the mobility of its dominant life-forms, this subformation occurs highest on rocks in the intertidal belt. There are two principal growth-forms—gasteropod, with spiral shell, continuous peristome, and close-fitting operculum, and associated with this in all situations except dry rocks above high-tide mark, where *Melaraphe* alone reigns, the limpet-like growth-form. Several associations may be distinguished.

This subformation is probably represented in all seas. I need only mention the associations of *Patella* and *Littorina* on the British coasts, of *Nerita* and *Tectarius* in the tropics, and of *Cellana* and *Melaraphe* in Australia.

Cellana-Monodonta Association.

Otago Harbour.—Rocks between tides at Portobello support a fairly typical harbour-community of shelled animals. The substratum consists of rather soft and easily weathered volcanic clay with a very irregular surface. It easily forms mud, hence the water is frequently turbid and the species consequently few. The shells also are in almost every case eroded, those of *Melaraphe cincta* and *Amaurochiton glaucus* being the most resistant. Most of the species are common throughout the association, and attain a large size.

Along the upper limit *Melaraphe cincta* (18 mm.), with clean non-eroded shells, is common. Here are a few patches of *Bostrychia arbuscula.* Below there follows the main collection, consisting of *Monodonta aethiops* (alt. 30 mm.), *M. corrosa, Sypharochiton pellisserpentis, Siphonaria zealandica* (25 mm.), *S. obliquata* (young), *Cellana ornata, Risellopsis varia* (diam. 8 mm.), *Patelloidea stella corticata*, and, on the larger shells, *Notoacmea daedala.* Along the lower edge of the association *Cantharidus tenebrosus huttoni* (alt. 14 mm.) is abundant. Other animals occurring on the rocks in fewer numbers are *Plaxiphora caelata, Ostrea angasi, Onchidella, Cominella lurida,* and *Euthria linea.* A little *Corallina officinalis* is found in rock-pools, whilst under stones occur *Amaurochiton glaucus* (always of a dark-green colour). *Notoacmea pileopsis*, and *N. daedala.*

Cellana-Melaraphe Association.

Shag Point.—Of the associations included under the gasteropod subformation the present is the richest that I have examined, both in number of species and in individuals. The size of the shells, too, is in most cases very large for the species. There is at Shag Point a wide intertidal shelf. The rock is not hard, being a yellowish sandstone containing many channels connected with the sea at low-tide, and higher up occasional pools, usually the result of the breaking-up of septarian boulders. The inner and upper

portion of this intertidal platform contains a remarkable collection of patelloid molluscs associated with immense numbers of *Melaraphe* of two species. All the crevices and water-channels are filled with molluscs. Three species of *Cellana* are almost equally common and mixed together, though they segregate to a certain extent. The shells are not badly eroded, though the apexes of the larger examples are seldom perfect. *C. strigilis* attains a length of 67 mm., *C. radians* of 51 mm., and *C. ornata* 47 mm. With these are associated equally plentifully *Siphonaria obliquata* (65 mm.), *Sypharochiton pellisserpentis*, and *Siphonaria zealandica* (23 mm.). *S. obliquata* occurs in clusters of fifteen to thirty, the shells often overlapping, on rocks fringing pools. Under water on the bottoms and sides of pools they deposit their ribbon-like spawn in large numbers. Each takes the form of a spiral of two to four turns, and of a diameter of 3 cm. to 4 cm. These spawns are frequently so crowded as to be touching. The spawns of *S. zealandica* are in the form of crescents, and are deposited in pools, often along with that of *S. obliquata*. *Melaraphe unifasciata* and *M. cincta* occur in immense numbers, sometimes densely clustered together. High up on the rocks *Notoacmea pileopsis* (26 mm.) occurs with *M. cincta* (20 mm.). Shells of *N. pileopsis* are perfect, but those of *M. cincta* are widely and often deeply eroded. Other molluscs, collected chiefly under stones, were *Monodonta nigerrima, M. coracina* (diam. 16 mm.), *M. lugubris*, and *Notoacmea daedala;* while *N. parviconoidea* was found on the rocks. Piles of seaweed are washed up everywhere, and emit a considerable smell. On *Macrocystis* so cast up *Monodonta nigerrima* occurs in incredible numbers, some with shells perfect, others with the black outer layer almost entirely removed, showing the nacreous layer below. Algae take but a small part in the *Cellana-Melaraphe* association. A *Corallina* with whitish fronds in some of the pools, and small tufts of *Ulva* on the rocks, were all that were noticed.

Cellana-Nerita Association.

Little Barrier Island.—The rocks here are for the most part large lava boulders. At one point the breccia of the cliffs is hard and compact enough to withstand the surf, and here the association is perhaps best developed. The dominant species are *Cellana radians* (40 mm., alt. 10 mm.) and *Nerita melanotragus*. With these are associated commonly *Monodonta aethiops, M. atrovirens* (diam. 27 mm.), *Turbo smaragdus, Sypharochiton pellisserpentis*, and, at a higher level, *Melaraphe unifasciata* and *Chamaesipho columna*. Conspicuous patches of the crustaceous brown alga *Leathesia* occur plentifully on rocks and on shells of *Cellana radians*. There also occur on *Sypharochiton*, and on the rocks, *Caulacanthus spinellus* and a filiform brown alga. The molluscs, which occur chiefly in the upper portion of the association where it is developed on the breccia cliffs, are *Cellana ornata* (33 mm., alt. 14 mm.), *Siphonaria zealandica, Notoacmea pileopsis* (22 mm.). *N. septiformis, N. parviconoidea*, and *Patelloida stella corticata*. Under stones occur *Atalacmea unguis-almae, Monodonta lugubris*, and *Actinia tenebrosa*.

Melaraphe Association.

Maori Papanui Bay, Otago Peninsula.—The rock here is hard volcanic, and, as elsewhere, *Melaraphe*, reaches highest above tide-marks. Only one species, *M. cincta*, was collected. Both young and adult occur, all with the spire of the shell more or less eroded. Adult shells are elongated; the largest measured 11 mm. Associated with *Melaraphe*, but not reaching

so high up the rocks, are *Cellana ornata* (21 mm.) and *C. strigilis* (30 mm.). Both species have eroded apexes; and, as shown by the measurements, only small specimens were found. Other molluscs observed in this association were *Notoacmea pileopsis* (small), *Monodonta atrovirens*, and *M. coracina*.

Takapuna.—Volcanic rocks about high-tide mark are bare of all algae except in damp crevices, where there may be a dark-brown crustaceous species. The dominant mollusc is *Melaraphe unifasciata*, which is found everywhere on the rocks, remaining in dry weather with the operculum closed and the edge of the outer lip of the shell attached to the rock by mucilage. At the lower border of this association the shells of *Melaraphe* are small (4 mm. in length or less); but on drier rocks above, where they extend among lichens, *Salicornia*, and *Poa*, they are larger (up to 10 mm. in length), elongated, and with the spire eroded. In crevices where the rocks are always more or less moist there may be small colonies of *Notoacmea pileopsis* and *Chamaesipho columna*. On the lower border of this association, where it merges into the *Chamaesipho* association, *Cellana ornata*, *Monodonta atrovirens*, and *Nerita melanotragus* are found.

Worser Bay, Wellington Harbour.—The only marine animals found above the wash of high tides are two species of *Melaraphe*—*M. cincta* and *M. unifasciata*. These occur on rocks, chiefly in crevices, up to $1\frac{1}{2}$ m. above high-tide mark. They are found above the lower limit of terrestrial vegetation, often sheltering beneath the pendent branches of *Mesembryanthemum australe*. They seal themselves up behind their opercula and attach the outer edge of the peristome to the rock by a little mucilage.

Burrowing-animals Formation.

The species which are found associating together in this formation appear to be more dependent on habitat than in the previously described formations. The dominant form, a free pelecypod mollusc, is practically confined to a microlithic substratum, and hence characterizes the formation. Many of the other members—crabs, worms, brittle-stars, and gasteropods—seem equally fitted for a rocky coast with its variety of substations. The difference between sand and mud, dependent on the movement of the water, determines the nature and variety of life. Fewest forms are found on the ocean-beach: thus the western coast of New Zealand between tide-marks is almost a desert. On the eastern coast, where calmer conditions obtain, well-marked associations are found. Coming into harbours, mud is the ruling factor; and with its greater stability comes a greater variety of life-forms—that is, more, crabs, worms, and gasteropods associated with the pelecypods. The essential features of a sand- or mud-loving pelecypod are the powerful foot for burrowing, and the extensile inhalent and exhalent siphons. In the intertidal species, too, the shells are close-fitting.

The relation of shell-sculpture to habitat has already been discussed. The dominant species of pelecypod in sand, *Amphidesma subtriangulata*, has a smooth, compressed shell; in mud, on the contrary, in *Antigona stutchburyi*, the commonest species, the shell is sculptured and ventricose. Reference has also been made to the turreted form of gasteropod shell which is characteristic of microlithic substrata. In the intertidal belt in New Zealand *Cerithidea bicarinata* is the largest species with a shell of this form.

The groups of associations in the two habitats, mud and sand, deserve the rank of subformations. The presence or absence of burrowing-crabs perhaps defines them. Besides the *Amphidesma subtriangulata* association,

on exposed sandy beaches there is one of *A. ventricosa* in certain parts of the west coast, but I have no details. A different association is found on more sheltered beaches—as, for instance, *Dosinia-Tellina* in Rangitoto Channel. On mud-flats the presence of *Cerithidea bicarinata* in the north, and its absence in the south, defines distinct subassociations of the *Antigona* association.

Hedley describes associations on sand and mud in New South Wales. The *Donax deltoides* association on sandy beaches may be compared with the *Amphidesma subtriangulata* association in New Zealand, while *Pyrazus herculeus* on mud seems comparable with *Cerithidea bicarinata*. Southern, in his description of Clare Island, does not indicate the dominant species, and I have seen only an extract of Davenport's account of Cold Spring Harbour. Probably a formation of similar structure to that of the burrowing-animals formation here described occurs on intertidal mud and sand in all parts of the world.

Amphidesma Association.

Tauranga.—At Maunganui Beach there is, exposed to the ocean between tides, a wide stretch of nearly level sand. The whole of the life here appears to be burrowing-animals, pelecypods being dominant. With them are associated some large gasteropods and various crustaceans.

In certain areas *Amphidesma subtriangulata* occurs in immense numbers. In April all the specimens gathered were small—45 mm. and under. They remain just below the surface, in a vertical position. Sometimes after a scour many thousands of shells may be seen partly exposed. The shells are clean, with the periostracum rubbed off around the umbones. Next in order of abundance to *Amphidesma* is *Antigona spissa*, occurring just beneath the surface of the sand. The shells are clean, variously coloured, and up to 30 mm. in length. Large gasteropods found in this association are *Struthiolaria papulosa*, *Verconella mandarina*, and *Cominella adspersa*. *Verconella* has clean uneroded shells, 130 mm. in length, and is found burrowing in sand near rocks. One shell had been severely attacked by burrowing-animals, which had removed a large portion of the outer layers; untouched parts were scarcely eroded at all. The *Cominellae* are clean, with the colour-pattern clearly marked, and the surface with more the appearance of having been worn than eroded. Shells gathered have a length up to 52 mm., and the shoulder not well marked. Crustacea include the swimming-crab (*Platyonischus bipustulatus*), hermit-crabs (*Eupagurus novae-zealandiae*—plentiful near the rocky coast), and a small isopod which runs quickly across the sand.

Monodonta excavata is found attached to smooth stones, usually at or just below the surface of the sand. The base of the shell is concave, and the periphery of the body-whorl angled. This may be related to the animal's habit of pushing its way beneath the sand covering the base of the rocks. Obviously, too, a larger amount of water can be held in the excavated base than in the body-whorl alone. (Plate 49, fig. 1.)

Dosinia–Tellina Association.

Rangitoto Channel.—At Cheltenham Beach the whole bay between the heads is laid bare at low tide. The surface is clean sand, but at a distance averaging 5 cm. below it is black. The biotic community consists of burrowing-worms, brittle-stars, and pelecypods beneath the surface, with sand-dwelling gasteropods, crabs, and starfishes above.

Burrowing deepest into the sand are *Nephthys macrura* and other worms. With them, though rare, are brittle-stars belonging to a long-armed species like *Amphiura aster*. They remain with their body some 10 cm. below the surface, but the tips of their arms project and sweep about in search of food. The large pelecypod *Pinna zealandica* is (1915) found in fair numbers near low-tide mark. The shells are 20–22 cm. in length, and stand vertically in the sand with only 1·2 cm. of the broad posterior end projecting above the surface. The byssus, which leaves the shell near the buried anterior end, spreads out, and at the end of each thread is attached a grain of sand. This holds as fast as if attached to a fixed object, for if the shell be forcibly taken from its position the byssus invariably breaks at its origin in the foot of the animal. The exposed ends of the shell support a little algae, *Elminius modestus*, and worm-tubes. A crab lives commensally within the *Pinna* shell. Occurring more generally over the flat and just below the surface of the sand are *Dosinia subrosea* (some with shells stained black), *Tellina liliana* (68 mm. in length and under), *Myodora striata* (common near low-tide mark), *Antigona stutchburyi* (common inshore, where it is said to have been planted), and *Amphidesma novae-zealandiae*. Less commonly found living here are *Callanaitis yatei*, *Mactra ovata*, and *Soletellina nitida*. All the pelecypods are clean and little eroded.

Gasteropods occurring in this association belong to two groups—firstly, the sand-dwelling species proper, including *Alcithoe arabica*, *Struthiolaria papulosa*, *Ancilla australis*, and occasionally *Calliostoma pellucidum*; and, secondly, the carnivorous *Cominella adspersa*, which occurs also on rocky shores. *Alcithoe* and *Struthiolaria* are found near low-tide mark, where they plough their way along just below the surface. *Ancilla* occurs more generally over the flat, and, like the others, moves beneath the sand. The shells of these species are fairly clean and but little eroded. Living beneath the sand, they remain in moist conditions during the retirement of the tide; and it is perhaps significant in this connection that the operculum is rudimentary in all of them. *Cominella adspersa* moves along the surface or occasionally just below it, preying on pelecypods, especially *Myodora striata*. Its shells are usually covered with slime and minute algae, and occasionally there may be some small *Elminius*.

Hermit-crabs (*Eupagurus novae-zealandiae*) are common on the mud-flat, occupying gasteropod shells mainly belonging to species inhabiting the adjacent coast. Starfishes—*Patiriella regularis* and *Asterias calamaria*—roam about near low-tide mark. Occasionally the curious *Callianassa filholi* is found.

Antigona Association.

Tauranga.—Sandy mud, black a little way beneath the surface, perhaps describes best the extensive flats not occupied by *Zostera* between tide-marks in Tauranga Harbour. Two strata of life are represented: the subsurface fauna consists of burrowing-crabs, worms, and pelecypods; on the surface are gasteropods, both vegetable-feeders and predacious kinds, supporting on their shells a few small animals of the tent-like form. A button-like alga is found here and there, usually near low-tide mark, where is is associated with a sponge and a small brown alga.

The flats are riddled with the burrows of the crabs *Heterograpsus crenulatus* and *Hemiplax hirtipes*. In making their burrows they bring up quantities of black sand, which makes the entrances conspicuous. Just beneath the surface *Antigona strutchburyi* abounds. The shells are usually

small, with high concentric ribs, and with the posterior end often eroded, stained, or attacked by a borer. *Tellina liliana* occurs in fewer numbers.

Scattered thickly over the surface of the mud are *Cerithidea bicarinata* and *Cominella lurida*. The latter animal is carnivorous, and is often found congregated in large numbers round its prey. I counted forty-two clustered round a dead crab, and seventy-five round a *Tellina*. *Antigona* frequently falls a prey to this mollusc. The whole outer surface of the shells of *Cominella lurida* is generally eroded and stained. The upper spire-whorls of *Cerithidea bicarinata* are always eroded. *Monodonta subrostrata* is usually found on stones lying about the mud. *Cominella adspersa*, *C. maculosa*, and *Turbo smaragdus* occur commonly, all with the spire more or less eroded. In certain places, usually near high-tide mark, *Amphibola crenata* is abundant. The shells of the species, though often stained, are very successful in resisting erosion. The protoconch may frequently be recognized in adult shells. Among animals habitually attached to the shells of the larger molluscs are sea-anemones, on the posterior end of *Antigona* shells; *Crepidula crepidula*, on *Turbo smaragdus*; small *Amaurochiton glaucus*, *Elminius modestus*, and *Notoacmea parviconoidea*, on *Turbo* and *Amphibola*.

Parenga Harbour.—Mud-flats between tides where not covered by *Zostera* are occupied below the surface by crabs, *Helice crassa*, and a few *Antigona stutchburyi*. The shells of this species here measure as much as 40 mm. in length, whilst in the adjacent *Zostera* beds the usual size is about half this. On the surface in this association are *Amphibola crenata*, *Cerithidea bicarinata* and *Cominella lurida*. Shells of *Cerithidea bicarinata* attain a length of 33 mm.; the largest shell gathered on the *Zostera* beds was 22 mm. long.

Heathcote Estuary.—Mud-flats without *Zostera* or algae occupy the greater portion of the Heathcote Estuary. Everywhere are crabs' burrows occupied by *Helice crassa* and *Heterograpsus crenulatus*. Just beneath the surface of the mud is *Antigona stutchburyi*, while deeper, about 10 cm. from the surface, is found, but less commonly, the larger pelecypod *Mactra ovata*. Everywhere down to a depth of 10 cm. to 15 cm. are worms of the species *Scoloplos cylindrica* and *Aricia papillosa*. On the surface *Amphibola crenata* is abundant. Equally common are *Monodonta corrosa* and *Cominella lurida*, all three species having the shells considerably eroded. On the larger shells there occur small specimens of *Notoacmea pileopsis*. The banks along the edge of the mud-flats are burrowed into by *Helice crassa*; under stones on the flat are *Heterograpsus crenulatua*, *Melita inaequis*, and the worms *Nereis kerguelenensis*, *Nephthys macrura*, and *Scolecolepides benhami*. (Plate 49, fig. 2, Lyttelton Harbour.)

Phytia Association.

Rangitoto.—Among rocks near high-water mark on the south coast of Rangotito there is a good deal of mud, and here is developed an association perhaps related to the mud-flat associations in the same way as *Melaraphe* and *Elminius* associations on rocks are related. The animals are tolerant of mud, and can live for more than half their time out of water. Two of the members of this association are pulmonates. *Phytia ornata* is the dominant form, and is abundant on mud in shady places and under stones; *Marinula filholi* is not so common. Other members of this association, which comprises only small species, are *Acmella neozelanica*, among green filamentous algae and under stones, and *Potamopyrgus*

antipodum, which is abundant on mud. Crustacea include the crabs *Heterograpsus sexdentatus* and *Heterozius rotundifrons*, the shrimp *Betaeus acquimanus*, and a fast-running isopod.

Grass-wrack Formation.

Zostera beds occur on mud-flats between tides in harbours throughout New Zealand. They extend from about half-tide mark down to below low-water level. They appear to be as equally well developed in Parenga Harbour, near the North Cape, as in Paterson Inlet, Stewart Island. The substratum varies from soft deep black and evil-emelling mud to nearly pure sand. It is only on a few sheltered beaches, however, that *Zostera* is found in sand, and the patches are always of small extent. Three strata of life are to be distinguished in this formation—a subsurface layer of burrowing pelecypods, crabs, and worms; a surface layer of gasteropods; and the green vegetative portion of the *Zostera*, with its herbivorous gasteropods. The rhizomes of *Zostera* are matted, thus giving a firm hold, while the leaves completely cover the surface, which they protect from tidal scouring. The chief feature of *Zostera*, however, is the ribbon-like form of the leaves, evidently an adaptation to tidal currents. According to Ostenfeld (*Rep. Danish Biol. Sta.*, vol. 16, p. 6, 1908), the leaves contain air, which causes them to stand upright in the water.

There is an extensive literature on *Zostera*. Here will be noticed that Southern describes an intertidal formation in Clew Bay, west of Ireland, and Hedley gives an account of the *Zostera* association between tides in Sydney Harbour.

Tauranga.—At Sulphur Point is an extensive area of flats between tide-marks covered with *Zostera*. The substratum is sandy mud, black immediately below the surface; the surface is slightly uneven, so that water lies in wide, shallow pools, and the association is consequently, for the most part, quite wet while the tide is out. The rhizomes of *Zostera nana*, with their roots and leaf-bases, form, just below the surface, a dense mat of vegetation, which effectually holds the mud together. Above the surface their short leaves, 10–15 cm. long, practically cover the ground, which is thus fairly well protected from the scour of the tide. Crabs' burrows are common. Descending obliquely for a few centimetres they then extend horizontally. Three species were collected—*Heterograpsus crenulatus*, *Helice crassa*, and *Hemiplax hirtipes*. *Antigona stutchburyi* is abundant just below the surface, but only small specimens, with shells 23 mm. and under in length, were observed. The posterior portion of the valves was eroded and stained. *Nucula hartvigiana* appears to be common, also small examples of *Tellina liliana*.

Molluscs occurring on the surface of the mud are *Cominella adspersa*, *C. maculosa*, *C. lurida*, *Cerithidea bicarinata*, and small *Neothais succincta*, all with the shells more or less eroded. On the *Zostera* leaves are herbivorous gasteropods—*Turbo smaragdus*, *Monodonta subrostrata*, and *Cantharidus tenebrosus huttoni*. Certain animals habitually rely on molluscs to carry them about. Sea-anemones attach themselves to the shells of *Antigona stutchburyi*. *Turbo smaragdus* here carries large loads: there may be a colony of *Vermilia carinifera* as bulky as the *Turbo* shell, or there are found *Crepidula crepidula*, *Notoacmea parviconoidea*, or algae containing *Dardanula olivacea*. The *Crepidula* itself is sometimes covered with *Vermilia* and *Spirorbis*. *Amaurochiton glaucus* is found on the larger shells of *Cominella adspersa* and *Neothais succincta*.

Among *Zostera* in shallow pools are shrimps, small crabs, and *Haminea zealandica.* Also, attached to *Zostera* leaves and other objects, are two species of a sea-anemone and a small button-like alga. Common in these shallow pools are little clumps of *Corallina officinalis* entangled with a sponge, on which are found numbers of *Cerithidea subcarinata*, *Dardanula olivacea*, turbellarians, and small crabs.

Notoacmea scapha I have found in other parts of Tauranga Harbour not far from Sulphur Point.' It was observed only on the leaves of *Zostera*. The shell is narrow, not wider than the leaf, and about twice as long as broad. It thus differs in shape from all the other New Zealand species of Acmeidae, and the peculiar outline is evidently related to its station. By not projecting beyond the margin of the *Zostera* leaf it offers the minimum amount of resistance to the action of tide and waves.

Parenga Harbour.—On mud-flats between tides in the most northern harbour in New Zealand are extensive areas covered with *Zostera nana*. Beneath the surface are many crabs of the species *Hemiplax hiritpes*; also the pelecypods *Antigona stutchburyi*, 20 mm. and under in length, and *Nucula hartvigiana*. On the surface the following gasteropods are found: *Lepsiella scobina*, large shells up to 35 mm. in length and with the entire outer surface eroded, and often supporting *Vermilia carinifera*; *Turbo smaragdus*, fairly clean shells with eroded apex and carrying *Crepidula crepidula* and *Vermilia carinifera*; *Cominella lurida*, with outer surface entirely eroded; *Monodonta subrostrata*; *Cerithidea bicarinata* and *C. subcarinata*. The chiton *Acanthochiton zealandicus* also occurs in this association.

Golden Bay, Stewart Island.—Between tide-marks are areas of sandy flats covered with *Zostera*. Compared with other parts of New Zealand this is a fairly rich association, with large molluscs. Burrowing beneath the surface are *Hemiplax hirtipes*; *Antigona stutchburyi*, up to 46 mm. in length, slightly discoloured, low sculpture, and rounded not ventricose valves; *Paphia intermedia*, 43 mm.; *Amphidesma novae-zealandiae*, 50 mm., with dark-coloured periostracum; and *Tellina liliana*. On the surface there occur *Alcithoe arabica elongata*, with shells that show a good deal of erosion but are not discoloured, and show also the colour-pattern on the body-whorl. On *Zostera* leaves are *Trophon ambiguus*, *Monodonta atrovirens*, and *Cantharidus tenebrosus huttoni*.

A feature of the *Zostera* beds are loose stones lying about. They support *Elminius modestus*, *Mytilus planulatus*, *Monodonta aethiops*, *Siphonaria zealandica*, *Hormosira Banksii*, and other small algae. On the under-side are *Euthria linea*, *E. flavescens*, *Neothais lacunosa squamatus*, *Amaurochiton glaucus*, *Ischnochiton campbelli*, and various worms. These rock-associations are evidently but detached portions of a shelled-animals formation of the adjacent rocky coast.

Salt-reed-swamp Formation.

In many harbours in New Zealand the outer fringe of salt reed swamps is invaded by tidal waters. In such places part of the marine fauna of the adjacent mud-flats is found.

Tauranga Harbour.—Along the landward border of tidal mud-flats considerable stretches of the shore are occupied by salt reed swamp, of which the species occupying the outside edge are *Juncus maritimus* and *Leptocarpus simplex*. High tide floods a strip of varying width, and here burrowing in the mud is the crab *Helice crassa*, and on the surface the gasteropod *Amphibola crenata*. Farther inland other species of plants enter, and there are often mud lanes lined with *Samolus repens*

and *Selliera radicans.* Here also are found the same two species of marine animals. Patches of *Scirpus americanus* occur out on the flats, with *Zostera* as an undergrowth. There is also an association of *Scirpus americanus, Triglochin striatum,* and *Paspalum distichum,* with *Helice crassa, Amphibola crenata,* and *Potamopyrgus antipodum.*

Mangrove Formation.

Mangrove is a formation of woody plants growing in mud between tide-marks, and includes, besides shrubs, a surface and subsurface marine fauna. The animals are similar to those of the adjacent mud-flats, but apparently poorer in species—at least, in the only locality that I examined. Very interesting ecological relations have been described for mangrove, but only two points will be mentioned here. In *Avicennia officinalis* horizontal roots below the surface of the mud give off many erect peg-like pneumatophores projecting to 30 cm. or so above the mud and functioning as respiratory roots. As a provision for quickly becoming fixed in the mud the embryo before it falls from the tree germinates as far as bursting the seed-coat, providing rudimentary roots and green cotyledons. An account of the New Zealand mangrove has been given by Cockayne (1921, p. 65; also *N.Z. Plants and their Story,* p. 35, 1919). Further details of the ecology of mangrove formations, with references to literature, will be found in the works of Warming (1909, p. 234) and Schimper (1903, p. 395). Mangrove is found in New Zealand in all tidal estuaries and inlets as far south as Kawhia and Tauranga Harbours. (Plate 50.)

Auckland Harbour.—In Shoal Bay the mangrove is small, but all of even height—about 1 m. It covers an extensive area near the level of high tide. The muddy floor is very soft, and therefore badly aerated; but the mangrove makes up for this by its pneumatophores, which rise at close intervals from the subsurface roots. The mud is riddled with burrows occupied by the crab *Helice crassa.* On the surface is *Amphibola crenata,* with small shells (25 mm. and under) covered with green slime. Near the land edge of the mangrove, *Potamopyrgus antipodum, Phytia ornata,* and small amphipods are abundant.

IV. LITERATURE.

A large amount has been written on algal ecology, chiefly in Europe. Cotton (1912, p. 12) gives a *résumé* of the work published up to 1912, also a bibliography including over eighty titles. In the list of papers following I therefore give only those published subsequently to 1912, or those omitted by Cotton, which deal with synecology of the littoral belt. For literature on the ecology of single groups of algae reference should be made to the reviews in the *Journal of Ecology* (see especially vol. 8, p. 66). The literature on animal ecology in the littoral belt is not extensive, most of it emanating from the United States. Lastly, papers which give descriptions of littoral formations of both plants and animals have, so far as I am aware, been contributed only by Australian zoologists.

Algal Communities.

1897. Kuckuck, P., Beitraege zur Kenntniss der Meeresalgen Wissensch., *Meeresuntersuchungen, N. F.* Bd. 2.

1898. Schimper, A. F. W., *Plant Geography upon a Physiological Basis.* English edition; Oxford, 1903.

1909. Warming, E., and Vahl, M., *Oecology of Plants.* English translation; Oxford.

1912. Cotton, A. D., Clare Island Survey, Part 15, Marine Algae. *Proc. Roy. Irish Academy,* vol. 31. 178 pp.

Fig. 1.—Tunicate (*Cynthia*) formation, low-tide belt, Auckland Harbour.

Fig. 2.—Long Beach, Bay of Islands. Under-side of stones in rock-pool at low-water mark. The tunicates are *Corella* sp. on the right and *Styela caerulea* on the left.

Face p. 544.

FIG. 1.—Animal and plant formations between tide-marks, Takapuna. Above, *Chamaesipho columna*; centre, *Ostrea cucullata*; below, *Corallina-Hormosira.*

FIG. 2.—*Vermilia carinifera* on reef in Auckland Harbour.

Fig. 1.—*Amphidesma subtriangulata* exposed on sandy beach between tides. Mount Maunganui, Tauranga.

Fig. 2.- *Amphibola crenata* on intertidal mud-flats, Lyttelton Harbour

Interior of mangrove forest, Mahurangi River.

1912. JOHNSON, D. S., and YORK, H. H., The Relations of Plants to Tide-levels, *Johns Hopkins Univ. Cir.* 6 pp.
1912. JONSSON, H., *The Marine Algal Vegetation of Iceland.* Copenhagen. 186 pp.
1913. DAVIS, B. M., A Biological Survey of the Waters of Woods Hole and Vicinity, Part 1, Sec. 2—Botanical, *Bull. U.S. Bureau Fish.*, vol. 31, p. 443.
1913. TRANSEAU, E. N., The Vegetation of Cold Spring Harbour, Long Island, I, The Littoral Successions, *Plant World*, vol. 16, pp. 189–209.
1918. MACCAUGHEY, V., Algae of the Hawaiian Archipelago, *Botanical Gazette*, vol. 65, pp. 42–57, 121–49.
1921. COCKAYNE, L., *The Vegetation of New Zealand*, pp. 63–67. Leipzig.

ANIMAL COMMUNITIES.

1903. DAVENPORT, C. B., The Animal Ecology of the Cold Spring Sandspit, with Remarks on the Theory of Adaptation, *Decennial Publ. Univ. Chicago*, 1st ser., vol. 10, p. 157.
1909. KING, L. A. L., and RUSSEL, E. S., A Method for the Study of the Animal Ecology of the Shore, *Proc. Roy. Phys. Soc. Edin.*, vol. 17, pp. 225–53.
1913. PEARSE, A. S., Observations on the Fauna of the Rock Beaches at Nahant, Massachusetts, *Bull. Wis. Nat. Hist. Soc.* (n.s.), vol. 2, p. 8.
1915. SOUTHERN, R., Clare Island Survey, Part 67, Marine Ecology, *Proc. Roy. Irish Acad.*, vol. 31. 110 pp.

PLANT AND ANIMAL COMMUNITIES.

1915. HEDLEY, C., An Ecological Sketch of the Sydney Beaches, *Jour. Roy. Soc. N.S.W.*, vol. 49, pp. 15–77.
1915. OLIVER, W. R. B., The Mollusca of the Kermadec Islands, *Trans. N.Z. Inst.*, vol. 47, p. 562.
1917. JOHNSTON, T. H., Ecological Notes on the Littoral Fauna and Flora of Coloundra, Queensland, *Queensland Naturalist*, April, 1917, pp. 53–63.

V. CONCLUSION.

In the foregoing account little more has been given than a definition of the principal formations of animals and plants in the intertidal belt in New Zealand, with a short description of some characteristic associations. I have also, under the heading "Ecological Relations," endeavoured to reduce to order the more obvious of the vast number of facts of an ecological bearing that can be gathered along the seashore. In reality no more than the fringe of the subject has been touched. Behaviour, which is an important branch of animal ecology, and the seasonal changes in both the fauna and the flora have not been studied at all. All these phases of the subject require careful investigation over long periods of time, whereas my studies have mainly been confined to the examination of associations and specimens. However, the present attempt at giving a connected account of life between tide-marks will at least serve to draw attention to the practically untouched field that exists there, and to the deeply interesting nature of the subject, which deals with a region where animals and plants mix in more equal proportions than elsewhere. If this effort acts as an incentive to other investigators to take up the subject the author will have the satisfaction of knowing that his work has been useful.

Life in the intertidal belt is representative of so many classes of animals and plants that it has been impossible to identify even the most conspicuous forms without the assistance of specialists. For naming specimens I therefore wish to tender thanks to Professor Chilton, D.Sc., F.L.S., to whom I submitted crustacea on various occasions; to Mr. R. M. Laing, M.A., and Mr. W. A. Scarfe, both of whom have supplied names of algae; and to Professor Benham, D.Sc., F.R.S., who furnished names for various worms. In all classes, however, I myself am largely responsible for the identifications, so that errors appearing in this paper must be attributed to me.

Art. 37.—*On the Behaviour of certain New Zealand Arboreal Plants when gradually buried by River-shingle.*

By C. E. Christensen, Head Masseur, Tourist Department, Rotorua.

[*Read before the Philosophical Institute of Canterbury, 3rd December, 1919; received by Editor, 21st December, 1921; issued separately, 22nd May, 1923.*]

Plates 51–53.

Introduction.

The River Perceval rises on the southern slopes of the Mount Perceval Range, flows through a rather narrow valley bounded by high tussock-covered hills, and finally, after a course of about five miles, emerges on the Hanmer Plains. At a certain point the river for a number of years has been raising its bed, and during this period has invaded the neighbouring plant-associations.

No literature relating to the burial of woody plants by river-shingle has come to my notice, but there is an abundant literature regarding burial by sand on the one hand and sphagnum moss on the other. Though neither of these kinds of burial is identical with that of shingle, yet evidently there is a close connection between them. This is dealt with when considering the physiological relation of the buried shrubs to their new environment.

The observations on sand-dune plants were made at the mouth of the Waimakariri River, Canterbury, the sphagnum-moss plants at the top of Jack's Pass, Hanmer Springs, and the shingle-buried plants in the upper portion of the Perceval River bed, Hanmer Springs.

I should here like to record my thanks to Dr. L. Cockayne, F.R.S., for assistance given me in preparing this paper.

Sand-dune Plants.

Coprosma acerosa A. Cunn. (the sand-coprosma) and *Pimelea arenaria* A. Cunn. (the sand-pimelea), both low-growing shrubs, can tolerate burial by sand, and with a slow drift can continue to grow upwards, owing to the power of putting forth adventitious roots from the uppermost branches.

Cassinia fulvida Hook. f. develops numerous rootlets when its branches are covered with sand.

Leptospermum scoparium Forst. also has the power to put forth adventitious roots where buried by the drifting sand, and seems to be none the worse when the sand has shifted and these accidental roots have withered.

Salix alba Linn. (the common willow) and *Sambucus nigra* Linn. (the common elderberry), where covered with drifting sand, put forth roots from trunk and branches. One elderberry, 15 ft. in height, had a number of these adventitious roots partially uncovered, some of them being many feet in length and up to 4 in. in diameter. The ends of these roots being buried in the sand enabled them to continue their functions, and in a few instances branches were growing from the larger roots.

SPHAGNUM-MOSS PLANTS.

The plants inhabiting the sphagnum-moss bogs have to grow faster than the moss or else be smothered: a slow-growing plant would very soon be covered and killed.

Nothofagus cliffortioides (Hook. f.) Oerst. can withstand a fair amount of burial, some of the trees that were examined being covered to the tips of the lower branches and still looking quite healthy.

Several plants of *Senecio Bidwillii* Hook. f. under observation were unable to grow as rapidly as the sphagnum moss, and in course of time were completely buried and killed.

Leptospermum scoparium, Dracophyllum uniflora, Discaria toumatou, Olearia cymbifolia, Gaultheria rupestris, Veronica buxifolia, Veronica glaucophylla, V. salicornioides, and numerous other shrubs and plants inhabiting the moss-bog manage to live and thrive through possessing the power of either putting forth adventitious roots or of being able to grow rapidly enough to keep well above the surface of the moss.

SHINGLE-BURIED PLANTS.

The shingle being moist and well aerated enables certain of the buried plants to put forth adventitious lateral roots, while others not possessing this property eventually die.

Numerous observations taken show that the moisture reaches to within 4 in. of the surface, and that there is a difference on sunny days of 20° between the surface-temperature and that of 6 in. below. For instance, on the 14th March, 1920, at 3 p.m. the thermometer registered 95° F. on the surface of the shingle and 75° F. 6 in. below.

Although the plant may be buried to a depth of 6 ft., the root-system proper does not seem to be at all injured. There are many examples of plants after a burial of some years having had the shingle removed and the adventitious roots withered, still flourishing as if nothing unusual had happened.

In very few instances have *Nothofagus cliffortioides* managed to survive the burial. Plate 51, fig. 1, shows one healthy specimen that still thrives in spite of having its trunk and lower branches deeply buried. Plate 51, fig. 2, shows one that did not survive. One dead tree had stones lodged in its branches some 8 ft. above the present level of the shingle.

Leptospermum scoparium and *L. ericoides*, where growing in the path of rapidly-moving shingle, are occasionally so badly injured that they die. (See Plate 52, fig. 3.) The action of the shingle is sometimes so severe that all the bark is worn off the trunk.

The following are a few examples of adventitious rooting:—

Rubus australis Forst. f.—The vine of this plant had only recently been uncovered, and during its period of burial it had developed many adventitious roots and fibrous rootlets, some of which were 12 ft. in length. An inspection of this plant eighteen months afterwards showed the uncovered roots to be withered, and to have practically disappeared.

Fuschia excorticata Linn. f.—The branches of this tree had been partially buried, and had put forth numerous roots from 1 ft. to 3 ft. in length.

Griselinia littoralis Raoul.—This tree was growing at the edge of some forest, and years previous to this observation had been buried deeply in shingle. Owing to a flood the shingle had been washed away and the trunk exposed. At a height of 4 ft. 6 in. above the present ground-level

adventitious lateral roots had been put forth; some of these were 12 in. long and $\frac{3}{4}$ in. diameter. From 1 ft. to 3 ft. above the surface other roots were growing, their extremities deeply buried in the shingle. These latter roots were very stout, measuring up to 3 in. in diameter. (See Plate 52, figs. 1, 2.)

Leptospermum ericoides A. Rich.—Height about 12 ft.; diameter 4 in. Trunk uncovered for 2 ft., showing long fibrous adventitious roots up to 9 ft. in length.

L. ericoides A. Rich.—Height approximately 10 ft.; diameter of trunk up to 4 in. Stem had been buried to a depth of 6 ft., and put forth numerous adventitious roots and fibrous rootlets. Branches that had been buried had also developed roots. (See Plate 53, fig. 1.)

L. ericoides A. Rich. -Height approximately 14 ft.; diameter 6 in. Trunk had been buried to a depth of 2 ft. above present level of the shingle, but now exposed and showing a mass of adventitious roots and fibrous rootlets. (See Plate 53, fig. 2.)

Coprosma propinqua A. Cunn.—This shrub can withstand much burial and damage to bark by the moving shingle, and behaves in a similar manner to *Leptospermum.*

Remarks.

The comparison made between the burial of certain plants by sand, moss, or shingle shows the close connection referred to in the commencement of this paper. The conditions necessary for the growth of adventitious roots are present in all three environments, distinct as they are from one another. Moisture and aeration are plentifully supplied, and, as shown, some plants that have adapted themselves to one environment are equally at home in the others. Advantage could be taken of the special properties possessed by these plants in using them to reclaim shingly wastes.

List of Species mentioned in these Notes.

Cassinia fulvida.
Coprosma acerosa.
Coprosma propinqua.
Discaria toumatou.
Dracophyllum uniflora.
Fuchsia excorticata.
Gaultheria rupestris.
Leptospermum scoparium.
Leptospermum ericoides.
Olearia cymbifolia.
Pimelea arenaria.
Nothofagus cliffortioides.
Senecio Bidwillii.
Sambucus nigra.
Salix alba.
Rubus australis.
Griselinia littoralis.
Veronica buxifolia.
Veronica glaucophylla.
Veronica salicornioides.

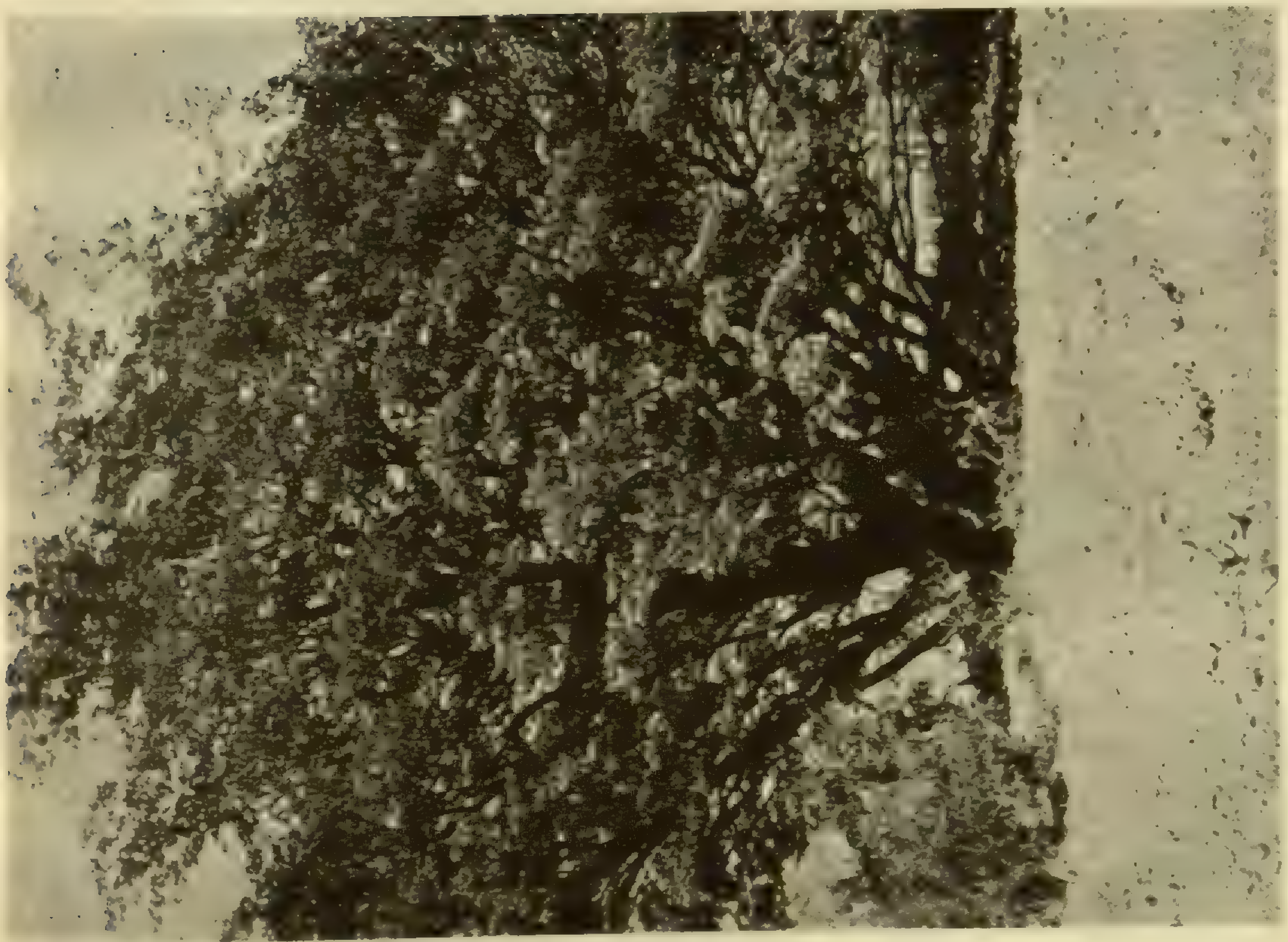

FIG. 1.—*Nothofagus cliffortioides* buried by shingle to its lower branches and still thriving.

FIG. 2.—*Nothofagus cliffortioides* that did not survive the burial.

Fig. 1.

Fig. 2.

Figs. 1, 2.—*Griselinia littoralis*, showing adventitious roots, marked ×.

Fig. 3.—The *Leptospermum* that died through its bark being worn off by the moving shingle: marked ×.

Fig. 1.

Fig. 2.

Figs. 1, 2.—*Leptospermum ericoides*, showing adventitious roots, marked ×.

ART. 38.—*Some Morphological Notes on the New Zealand Giant Kelp,* Durvillea antarctica *(Chamisso).*

By Miss E. M. HERRIOTT, M.A., Biological Laboratory, Canterbury College.

[*Read before the Philosophical Institute of Canterbury, 7th December, 1921; received by Editor, 15th December, 1921; issued separately, 22nd May, 1923.*]

Plates 54, 55.

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INTRODUCTION.

DURING the past years several references have been made to this fucoid in reports of the various Antarctic expeditions. Skottsberg, of the Swedish Antarctic Expedition, and Gain, of the second French Antarctic Expedition, have both recorded it from the smaller islands of the Southern Hemisphere, but have not given any details as to its anatomy. For such a study it is almost necessary to work with fresh material collected where the plant is growing. Plants that have been washed up and allowed to dry for any length of time give unsatisfactory results; the tissues shrink and the cells become distorted. Notwithstanding the abundant material available, and the interest of the plant as probably representing, in spite of its enormous size, one of the lowliest forms of its order, no account of its anatomy has been given by any New Zealand botanist. The greater part of this paper, including the anatomical sections, was prepared several years ago.

GENERAL.

Historical.

Durvillea antarctica was first recorded under the name *Fucus antarcticus* by Chamisso (*Voy. Choris*, p. 7, tab. 7). In 1826 Bory redescribed it in *Flore des Malouines* (p. 588), and formed a new genus, *Durvillea*, for its reception. He, however, bestowed on the plant a new specific name, *utilis*, disregarding the older name *antarcticus*. The plant was then known as *Durvillea utilis* Bory, and the error was not corrected till 1892, when Hariot pointed it out and restored Chamisso's specific name. Later, in 1908, Skottsberg also noted the mistake that had been made (1908, p. 140), though evidently he did not then know of Hariot's correction. The plant should now therefore be known as *Durvillea antarctica* (Chamisso) Hariot. For a list of synonyms and references see Gain's account of the plant (1912, p. 51). To these must be added a further reference by Skottsberg (1921, p. 52).

General Description.

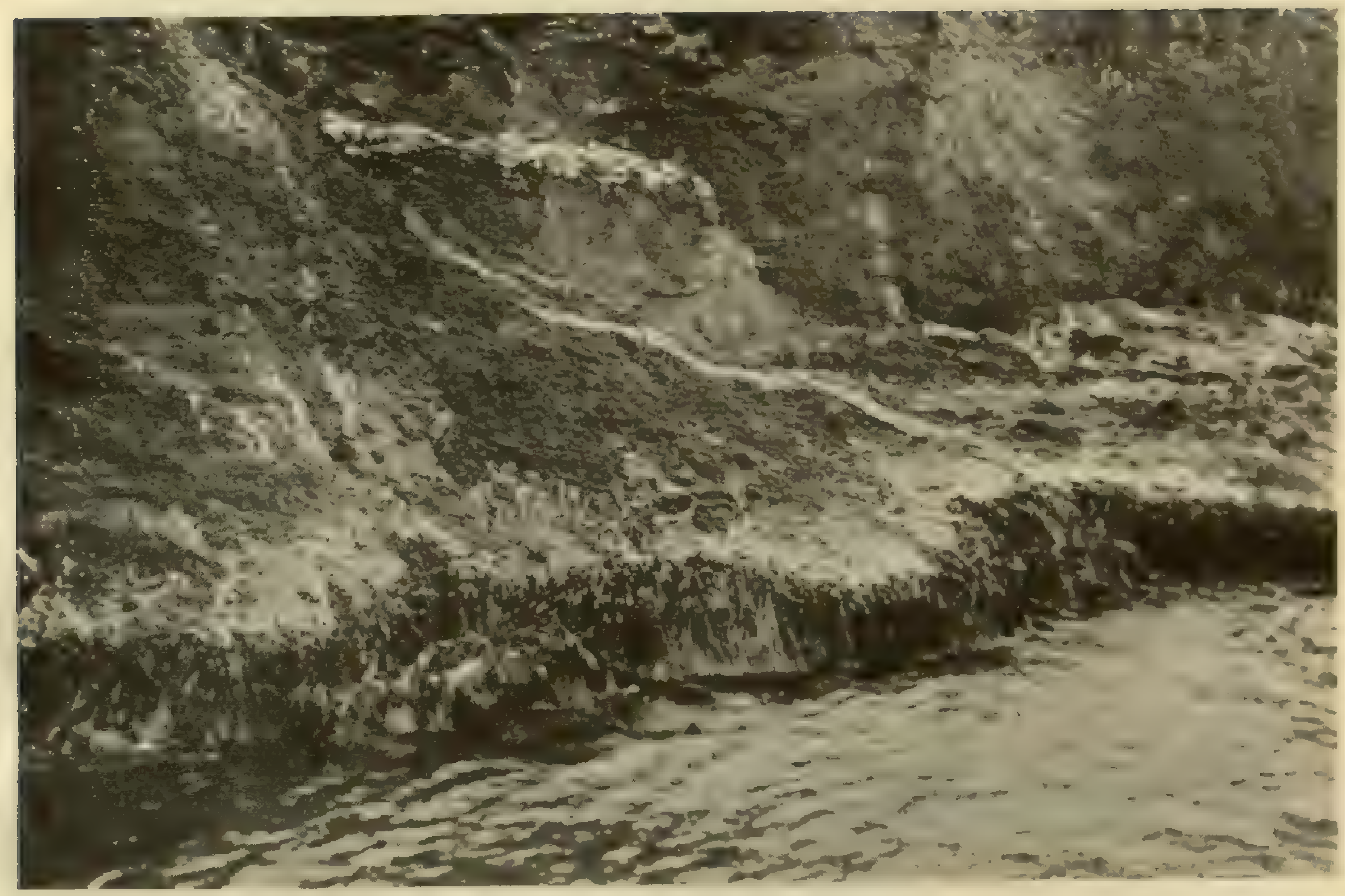
The genus *Durvillea* belongs to the order Fucaceae of the group Phaeophyceae, or Brown Algae. This order is distinguished by the complete absence of any method of asexual reproduction. As, however, Lloyd Williams has recently described sexual reproduction in the order Laminariaceae, where it had previously been supposed to be wanting, it is possible that future investigation may show some form of asexual reproduction in this order. Hooker's description of the genus is as follows: "Root scutate. Frond stalked, dark olive-brown or black, flat, expanded, very thick and coriaceous or honeycombed transversely internally, palmate or pinnate, without distinct organs. Fruit dioecious. Conceptacles scattered over the whole frond in the cortical stratum, containing either obovoid subsessile spores or branched filaments bearing obovoid antheridia" (1867, p. 654).

The genus belongs to the Southern Hemisphere, and usually two distinct species are recognized, *D. antarctica* and *D. Harveyi.* Of these, only *D. antarctica* is known from New Zealand. Hooker (1867, p. 654) describes the species thus: "Frond dark brown or black, often 30 ft. long, forming an immense flabellate palmately lobed laciniated lamina, contracted at the cuneiform base into a short stipes as thick as the wrist; segments or thongs often 1 in. thick, honeycombed internally."

The chief point of difference between the two species appears to be that in *D. antarctica* the lamina is much divided and inflated, whereas in *D. Harveyi* it is more or less undivided and solid throughout. Hooker (1847) also describes the "root" of *D. Harveyi* as fibrous, while in *D. antarctica* it is disc-like. Skottsberg (1921, p. 53) points out that Areschoug included all the South American forms in one species. He himself would retain the names *D. antarctica* and *D. Harveyi* for the two extreme forms, but he says that he has found at least one form which is intermediate between the two, and suggests the possibility of others being found to bridge the gaps, in which case a series might be formed connecting the two extremes. He also points out the different conditions under which these two so-called species are found. *D. antarctica*, with its much-divided lamina, is found where the surf is very violent, while *D. Harveyi* is found in much quieter waters, or in tide pools, and is not exposed to such severe treatment. A specimen to be described below from Bounty Island, and subjected to even severer conditions than those met with on New Zealand coasts, has its lamina much more divided than typical *D. antarctica*, a fact which may add further weight to the suggestion that the form of the plant depends on the habitat.

Distribution.

As regards the distribution, Skottsberg reports it from central Chile to Cape Horn, Falkland, Kerguelen Islands, New Zealand, Chatham, Auckland, and Campbell Islands. "It does not grow in South Georgia, but drifted pieces are sometimes found" (1921, p. 54). Gain, however (1912, p. 111), gave South Georgia as one of the localities in which *Durvillea antarctica* occurred. Hooker (1847) had described it as having been found floating in the sea off the Cape of Good Hope, and as far south as the 65th degree of latitude on the meridian of New Zealand.



[*L. Cockayne*, *photo.*

Fig. 1.—*Durvillea antarctica* growing at Cape Saunders, Otago Peninsula, N.Z.

[*L. Cockayne*, *photo.*

Fig. 2.—*Durvillea antarctica* growing on rocks uncovered by sea at low water, Dog Island, Foveaux Strait, N.Z.

Face p. 550.

Plant of *Durvillea antarctica*, much reduced.

Habitat.

Durvillea antarctica grows attached to rocks " on exposed rocky coasts or steep cliffs, often in narrow crevices where the surf is very violent. During dead low water it hangs from the rocks, with the whip-like segments washed by spray, or in calm weather almost dry for a short while. At high water the whole plant is violently tossed about in the breakers, and in stormy weather with tremendous force that would tear the strongest frond to pieces were it not split up into numerous laciniae, elliptical or circular in section " (Skottsberg, 1921, p. 53).

As Hooker noticed, *Durvillea* is generally associated with the other large brown kelp, *Macrocystis pyrifera*. *Durvillea* grows close to and attached to the rocks, forming huge banks of brown seaweed (Plate 54, figs. 1 and 2), which are dashed about in the water and against the rocks by every breaker, while *Macrocystis* forms a second zone farther out, and its thin leaf-like segments can be seen floating on the surface, rising and falling with each passing swell. The structures of these two seaweeds afford striking points of contrast. The frond of *Macrocystis* is enormously developed, and exposes as great a surface as possible for assimilatory processes, while the stipe is very slender. There is no strain on the stipe, its purpose being merely to connect the various portions of the frond and to act as a channel of conduction, for which purpose it has developed its peculiar sieve-tubes. In *Durvillea*, on the other hand, the stipe is of very considerable thickness, one having been measured of 12·5 cm. diameter. It grows out horizontally from the rock-face, and during low water has partially to support the huge segmented lamina which hangs from it ; it must consequently be tough and leathery, and yet very pliable, to meet the great strain upon it. Portions of the frond torn away from the plant may frequently be found, and sometimes the stipe itself is broken across. The force of the waves may even tear away the holdfast with portions of the supporting rock ; and on looking down at a bed of *Durvillea* one may see ample evidence of the rough treatment to which it has been subjected.

MORPHOLOGY AND ANATOMY.

Three distinct regions can be recognized in the plant-body. These may be called (1) the holdfast (the " radix " of Agardh and the " haftscheibe " of Skottsberg), (2) the stipe or " stem," and (3) the lamina (Plate 55).

(1.) *The Holdfast.*

The holdfast attaches the plant to the rock. It is usually quite regular and circular in outline, forming one continuous disc. In one specimen (fig. 1) collected on the New Brighton beach the tissue was torn apart, leaving fissures in the structure similar to that described by Grabendorfer for *D. Harveyi*. The upper surface is light-yellow in colour, much lighter than the lamina and stipe, the lower surface, which grows towards the substratum, being dark brown.

The holdfast grows stretched over the rock, adhering to it much after the manner of a leather sucker to a stone. The tissues grow round the jagged edges of rock and fit into the crevices, thus obtaining a firm hold. Holdfasts, of course, vary in size, according to the size of the plant attached, increasing in area as the plant increases in size from year to year. The diameter is always several times that of the stipe attached, the smallest plant measured, in which the three regions of the plant were differentiated,

having a diameter of 2·5 cm. for the holdfast and 3 mm. for the stipe. In some large specimens the holdfast measures from 30 cm. to 60 cm. across, and in these it is not uncommon to see several stipes arising from one holdfast: Agardh (1848, p. 188) mentions six as the highest number observed; the writer has seen four, three adult plants, several feet in length, rising from the central portion of the holdfast, and near the outer edge a small plant, measuring only 15 cm. in length, whose lamina was still a flat thallus which had not begun to segment (fig. 2).

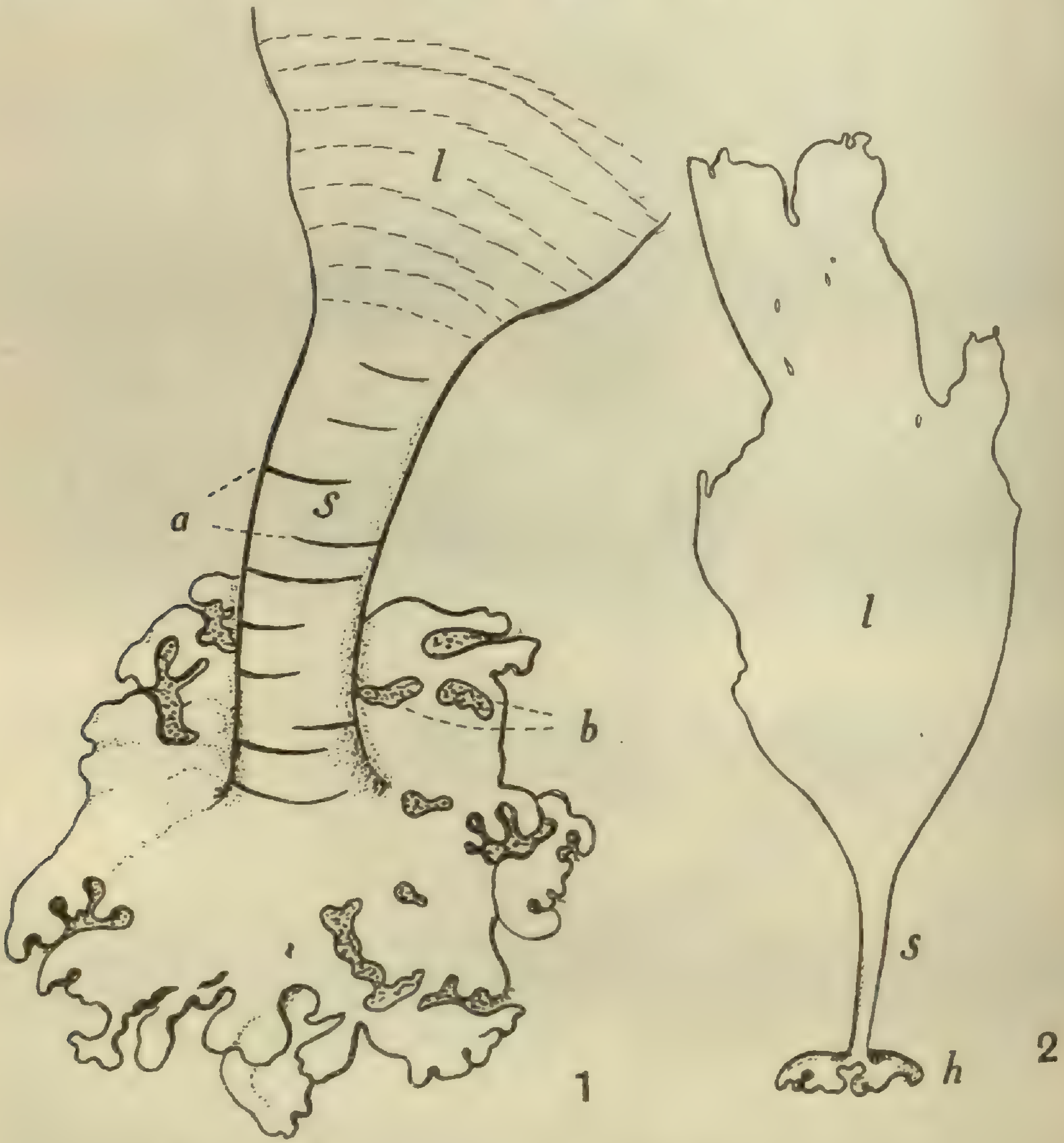


Fig. 1.—Holdfast, with portion of stipe showing pits, &c.
Fig. 2.—Small plant of *Durvillea antarctica* ($\times \frac{3}{4}$).

Where the plants grow together in such masses that the holdfasts of the separate plants have not sufficient room to develop independently, one will encroach on another, the two finally growing together, forming one common holdfast in which the tissues have united so completely that there is in most cases no mark to show where the union has taken place.

In one specimen examined the stipe seemed to branch just at its junction with the holdfast; but this apparent branching was probably brought about by the germination of two oospheres close together, so that the two holdfasts united at a very early stage, while the two stipes by growth

of the cambium layer increased in thickness, and finally met. Continued growth and the constant friction of the tissues may then have caused the adjoining tissues to unite, and so to appear finally as branches of one main stipe.

The tissue of which the holdfast is composed is very elastic; when pulled away from the rock it contracts greatly, the lower layers contracting most and drawing the upper layers over them. When washed up on the beach and left exposed the holdfast loses its water and contracts to a hard horny mass.

Figures 3 and 4 show details of the anatomical structure of the holdfast. These sections were cut from a young specimen. The tissue appears to consist of (*a*) an outer layer about seven cells in thickness, the cells being small and cubical or slightly rounded, abundantly filled with protoplasm and a light-brown colouring-matter. The outermost layer is not specially marked off from the underlying cells, as it is in both stipe and lamina.

Below this comes (*b*), a meristematic tissue composed of several layers of smaller cells in a state of active cell-division. On staining, each of these cells is seen to contain a large nucleus.

Below this again comes tissue (*c*), of small rounded cells, and this passes into the central tissue (*d*), consisting of large irregularly shaped cells with sparing cell-contents. This tissue makes up the greater part of the body of the holdfast. Its cells contain some small round bodies (fig. 3, *k*) which stain a faint yellow with iodine; this is probably the Phaeophycean starch of Schmitz (Zimmermann). The presence of such bodies in the holdfast would support the theory presented by Harvey (1849, Introduction, p. xx) that the holdfast acts as the storehouse for reserve food, and may be compared with tuberous or tap roots of higher plants.

On the under-surface of the holdfast are about three layers of cells which contain a dark-brown colouring-matter, as described by Grabendorfer (1885, p. 7) for *D. Harveyi*. Their function is probably protective.

Sections were also cut from older holdfasts. These had been exposed for some time to wind and sun, and had therefore lost much of their water. The outermost layer consisted of cubical shaped cells, but the great part was composed of very irregularly shaped cells embedded in a horny matrix, to which the peculiar woody appearance of a cut holdfast is probably due.

When such dried specimens are placed in fresh water they swell up enormously, but the constituent cells then present a very distorted appearance, with very irregular lumina. Such a section represents a structure very unlike that shown by fresh material. The study of dry material does not give satisfactory results in this case, and it is probably owing to the fact that Grabendorfer's examinations were made mostly on dry material that his descriptions of *D. Harveyi* are so hard to reconcile with examinations of *D. antarctica*.

In the holdfast growth is effected by a definite growing tissue (fig. 3, *b*), and in this it differs from stipe and lamina, in which growth is evidently effected by division of the outermost layer of cells.

(2.) *The Stipe.*

The stipe, as it arises from the holdfast, is cylindrical, but in most cases it gradually becomes flattened and passes into the lower portion of the frond In other cases the original stipe continues its growth, retaining its cylindrical form, while it gives off secondary stipes along its axis. This is the pinnate arrangement mentioned by Hooker (1864, p. 654). The secondary stipes then bear the segments of the frond. A small plant ot

this type had a primary stipe measuring 90 cm., and one of the secondary stipes, with its lamina, measured 2·55 m.

The stipe increases in thickness from year to year, the diameter in some of the larger specimens varying from 5 cm. to 7·5 cm.; one exceptionally large one measured 12·5 cm. Such thicknesses are exceptional for seaweeds, but in the case of *Durvillea*, as mentioned before, the stipe has partially to support its huge segmented lamina when it is left uncovered at low tides, hence its need of a stout tissue. The thickness of the stipe of *Durvillea* is exceeded by the big Laminarian *Postelsia palmaeformis*, whose huge stipe is strong enough to maintain an upright position in the air and support its tuft-like lamina (Campbell, 1902, p. 127).

Three distinct tissues may always be recognized in the stipe, whether young or old: (1) an outer cortical assimilatory layer, (2) a filamentous conducting tissue, and (3) a central tissue.

The surface layer of cells (figs. 5, 6, *a*) appears to be differentiated from the rest of the cortical tissue. The constituent cells are rather small, somewhat cubical in shape, and at the same time more densely filled with cell-contents. Below this comes the rest of the cortical tissue (*b*), several cells in thickness, containing abundant protoplasm and rich in brown colouring-matter. These cells are arranged in radial rows round the stipe. The innermost cells of this layer lose their characteristic oval form and show a tendency to branch and elongate. They pass gradually into the next tissue (*c*), which is a mass of interwoven filaments. In longitudinal section (fig. 6) these appear to lie close together, and run more or less in a longitudinal direction. In transverse section (fig. 5) they appear to be arranged in rows continuous with the rows of the outer layer. Towards the centre of the stipe this arrangement becomes less regular, and in figs. 5 and 6 (*c*) the longitudinal filaments are seen cut across. These filaments are interrupted by other septate filaments running in a transverse direction, which serve to bind them together and make the tissue firmer.

The central tissue (*d*) is composed of a mass of cells of varying shapes. There are few filaments to be seen both in transverse and longitudinal sections, but the greater part of this tissue is made up of large cells, arranged in chains, about ten times the size of the smaller ones of the outer tissues. These have sparing cell-contents, but contain small round bodies (*k*), similar to those of the holdfast, which probably represent the reserve food material in the form of Phaeophycean starch. This central mass of tissue appears much darker than the other two layers in a freshly cut stipe, but a section across does not reveal any cause for this. The contents are colourless, or nearly so. The two outer layers may also be distinguished in a fresh stipe by their colour. The outer cortical tissue is coloured a light brown, while the inner conducting tissue is nearly colourless, and merges gradually into the darker central tissue.

A stipe with a diameter of 4 cm. was taken and cut into thin layers about 0·5 cm. thick. Some were placed in water, others in 30 per cent. alcohol, and others in 50 per cent. alcohol, and left all night. In the morning the piece in water was much the same. Of the piece in the 30 per cent. alcohol, the outer tissue remained the same colour, the second tissue had become flesh-coloured, the central tissue being lighter; some of the dark colouring-matter had dissolved out. Of the piece in the 50 per cent., the outer tissues were the same as in the 30 per cent., but the central tissue had turned a bright green. When left longer in the alcohol this green colouring-matter dissolved out. A section of the central portion showed that the green colour was due to small round green bodies in the larger

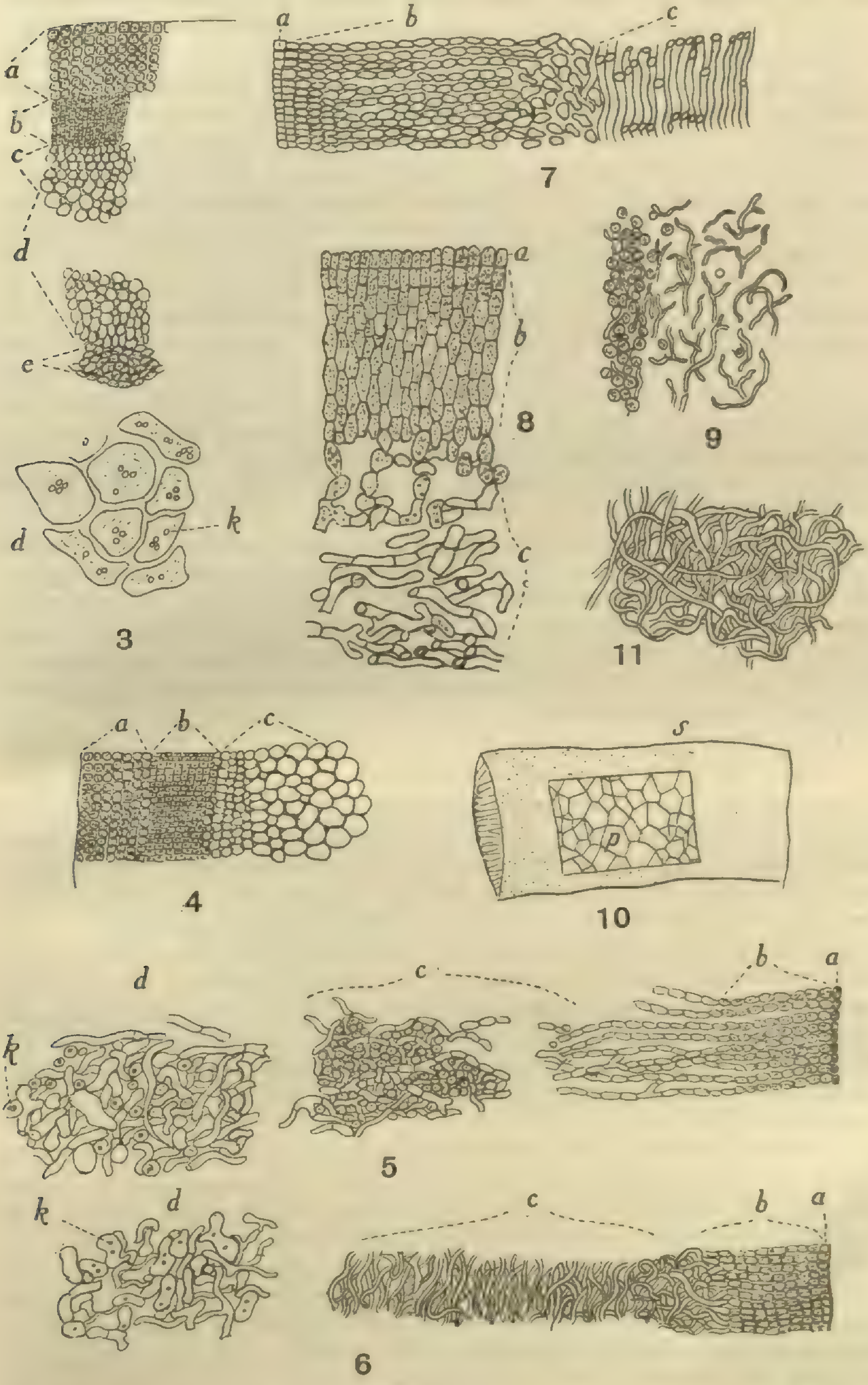


FIG. 3.—Vertical section of holdfast.
FIG. 4.—Tangential section of holdfast.
FIG. 5.—Transverse section of stipe.
FIG. 6.—Longitudinal section of stipe.
FIG. 7.—Transverse section of lower portion of lamina.
FIG. 8.—Transverse section of upper portion of lamina.
FIG. 9.—Tissue breaking down to form air-chambers.
FIG. 10.—Portion of lamina with upper tissue removed to show air-chambers.
FIG. 11.—Structure of wall of air-chamber.

cells of this tissue. These bodies would appear to be connected with the colourless bodies in the fresh specimen, and it is probable that they were identical with them.

Growth takes place as in the lamina by the active division of the outermost layer of cells, which are more densely filled with the brown colouring-matter than the other cells of the cortical tissue. These cells divide only from their inner side, and so give rise by continued division to the radial rows of the cortex. The cells of the cortex again gradually pass over into the next layer by continued growth, and so each tissue increases in size from the one directly outside it.

On experimenting with a stipe from an adult plant, after Detmer's method (1898, p. 20), to extract the brown colouring-matter from the outer layers, it was found that it differed greatly in this respect from portions of the frond. The colour of the stipe is always much lighter than that of the frond, and the brown colouring-matter is not extracted by boiling water or by alcohol, while it is readily extracted from the frond in either way, leaving the green chlorophyll in the cells.

The stipe used had a diameter of 6·25 cm., and a traverse section about 1·5 cm. long was cut in quadrants. These pieces were placed in hot water, and in half an hour the inner portion corresponding to the storage-tissue contracted greatly; the two outer layers did not contract at all, and were therefore drawn over this central portion. The same result is obtained in a less degree by cutting up a stipe and leaving it exposed to the air for a day or two. Hence it is seen that the inner tissues of the stipe are in a state of tension, and when the tension is released they contract owing to loss of water.

(3.) *Lamina.*

General Structure.—The original stipe usually gives rise to a palmately segmented lamina, which often attains a great length. Numerous specimens were measured that had been washed up after a strong gale. The smallest stipe of a group of four attached to one boldfast bore a lamina broken across part of its length, but the remaining portion measured 10·8 m. The lower portion of the lamina is a continuation of the stipe, and is usually flat and expanded, measuring from 30 cm. to 45 cm. in its widest part. This then divides up, more or less closely to the stipe, into numerous long whip-like segments, which appear to have arisen quite irregularly. The segments are of various lengths; some branch repeatedly, others remain unbranched and occasionally terminate bluntly, but usually each segment tapers to a fine point.

The broad lower portion of the lamina is solid throughout, but as it breaks up into segments the central tissue is torn apart, and forms air-chambers, in which gases collect, causing an inflated appearance in the fronds. Air-chambers are not always present, but there is usually some indication of them. On the segments occur the conceptacles, which contain the reproductive organs. The conceptacles cover the frond thickly, and may be recognized by the pores, or ostioles, which are plainly visible as little dots on the surface. In the winter months, which are the best for studying the reproductive organs, these ostioles are covered with the extruded contents of the conceptacles. These contents may be recognized by their colour; in the case of the oogonia they are dark brown, while the colourless antheridia show as white dots.

There are only two clearly defined tissues present in the lamina, the outer cortical or assimilatory, the inner medullary or conducting.

In the lower portion of the lamina where no air-chambers are present there are only two kinds of tissue; the inner storage-tissue of the stipe disappears. Fig. 7, a section of this portion of the lamina, shows the arrangement of this tissue. The outer layers (*b*) are composed of cells arranged in more or less regular radial rows. In sections which had been preserved in alcohol after picric acid these cells were flask-shaped, and the rows were distinctly separate. The cells were filled with darkly stained cell-contents. The inner cells of the layer lose their regular form, and show a tendency to elongate in various directions, and gradually to pass into the second medullary layer (*c*), which is composed of a dense mass of filaments running parallel to the longitudinal axis of the plant.

Sections of those segments of the frond which possess air-chambers show the same structure (fig. 8), but here the medullary tissue (*c*) is broken down in the centre of the very young portions of the segments, and the origin of the air-chambers can be seen (fig. 9).

Growth takes place here as noticed by Grabendorfer (1885) in the outermost layer of the lamina. These cells are richly filled with protoplasmic contents, and are in a state of active cell-division, both by tangential and radial walls.

Air-chambers.—The air-chambers found in the frond of *Durvillea antarctica* are a distinctive mark of this species; they increase the width of the segments of the lamina, their gases distending it considerably. The chambers vary in size and shape, but the largest measured was not more than 1·25 cm. across. They may be hexagonal, square, triangular, or quite irregular in cross-section, and are separated by walls at right angles to the surface (fig. 10). These walls are composed of interwoven filaments (fig. 11), each of which is surrounded by a gelatinous wall, clearly distinguished on staining with methyl blue. In fresh specimens the walls are tough and elastic, but when dried they become papery.

The gas contained in air-chambers of the Fucaceae was stated by early experimenters to be nitrogen. "Wille added to this oxygen, and denied the presence of carbon dioxide" (Murray, 1895, p. 48). Some of the gas was collected at Taylor's Mistake and brought up to Christchurch, and analysed with Hempel's apparatus. There was no CO_2 present. In 55 c.c. of the gas after passing it through KOH there was no difference in volume, thus proving the absence of CO_2. After treating with pyrogallic acid, 42·6 c.c. remained, thus giving a volume of 12·4 c.c. of oxygen present. This gives a percentage composition of 22·54 oxygen and 77·45 nitrogen, showing the gas to be richer in oxygen than ordinary atmospheric air. There are no special organs for absorbing the gases, which must therefore pass through the cell-walls in solution in the water, and they can do this only very slowly.

Professor Warming states that the fucoids are able to absorb every trace of air present in the surrounding water, and, when that is all absorbed, to draw on the stores of oxygen contained in the air-chambers, and so carry on the process of respiration. This would account for the state of collapse which has been noticed in some of these air-chambers, as in the seaweed which has been washed up in a shady place where little moisture can reach it. The gas can pass into the plant only in solution in water, and when no water is present the plant is compelled to draw on its reserve stock. When the plant is exposed to the sun the heat expands the gas, and so keeps the chambers distended, while it also dries up the tissue of the plant, so that the process of assimilation cannot go on.

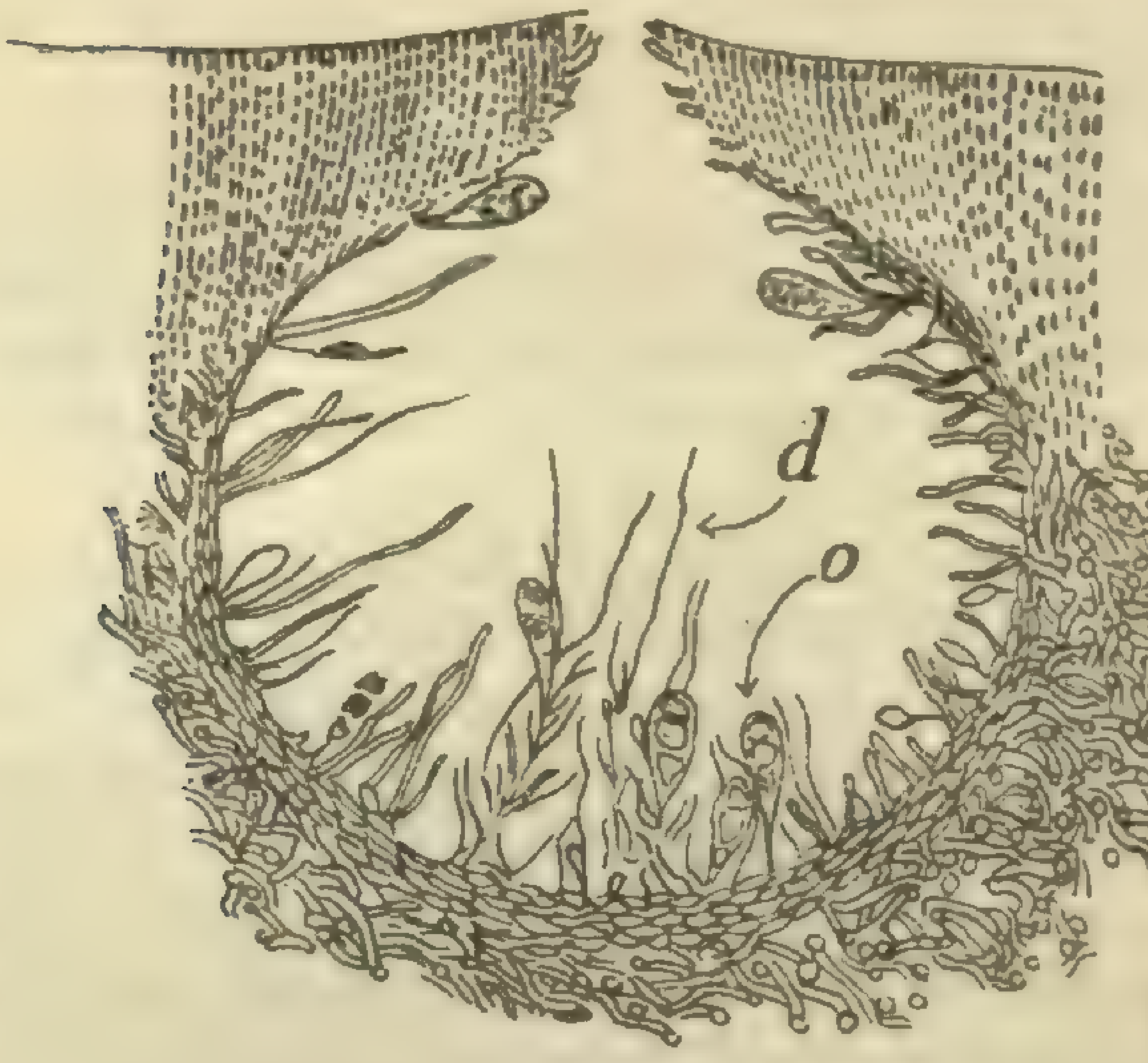
Conceptacles.—*Durvillaea* is dioecious, male and female conceptacles being found on different plants. The conceptacles are flask-shaped cavities (fig. 12), opening to the exterior by a narrow mouth, or ostiole. The conceptacle itself extends down into the medullary tissue, which is specially differentiated around it, forming a layer of two or three cells in thickness, composed of elongated cells tapering at both ends and dovetailing into one another. The structure of the conceptacle does not differ much in the male and female plants.

The apical cell, by division of which the conceptacles arise, does not persist as in *Splachnidium*, and there are no hairs protruding from the ostiole. The cells lining the cavity grow out into short papillae just near the mouth, the shortest being found nearest the exterior. Both male and female conceptacles are abundantly provided with hairs (*d*), both branched and unbranched, on which the sexual organs are borne. These hairs are the outgrowths of the cells lining the cavity, and they are found in various stages of development, some as short club-shaped papillae, others two or three cells in length; some branched, others again still unbranched. Each hair is surrounded by a thick gelatinous coat, which shows up plainly on staining with methyl blue. Its cell-contents contract somewhat, but take the stain much more deeply than the outer coat.

These hairs show a tendency to swell up at the end into a club-shaped body more densely filled with protoplasm. This is apparently the origin of the antheridia and oogonia.

In the female conceptacles (fig. 12) there are both branched and unbranched hairs (*d*), and the oogonia (*o*) are borne on both, or may be subsessile. Hooker (1864) found them to be subsessile, and in one specimen examined there were no branched hairs at all, the oogonia being directly attached by a basal cell to the wall of the conceptacle. In all the others there were numerous branched hairs, and the oogonia were in these found on lateral branches, although in some cases they were subsessile on the wall of the conceptacle. Mr. R. M. Laing (1885) stated that the older ones were found on branched hairs; but this is not always the case. There does not seem to be any distinct rule about their arrangement. Each oogonium is cut off, either from its basal cell or from the rest of the hair on which it arises, by a cell-wall. The outer coat can be always plainly recognized by a suitable stain. The oogonium is at first globular (fig. 12). It is rich in cell-contents, at first colourless but later on taking a faint yellow tinge, deepening to a dark-brown colour when mature. The young oogonium is also rich in food material in the form of small round bodies scattered in the granular protoplasm. The protoplasm divides into three transversely, the middle portion again dividing into two longitudinally, so that there are finally four oospheres within the oogonium (fig. 14). This mode of division was first noticed by Hooker, as stated by Hombron and Jacquinot (1845), and he called the four resulting oospheres "tetraspores." It was first rightly interpreted by Kutzing in his examination of *Sarcophycus potatorum* (*Phyco. Mem.*, p. 38). The four oospheres, surrounded by an inner coat, escape from the oogonium into the water outside the plant by rupture of the wall at the apex, and leave the empty oogonium still attached to the wall of the conceptacle.

Oogonia in all stages of development may be found in the same conceptacle. The colourless globular bodies were found in one in which the ripe dark-brown oospheres were being expelled. From this it would seem that the conceptacles are able to produce oogonia indefinitely by the continued activity of the cells lining the cavity. Mr. R. M. Laing (1885) states



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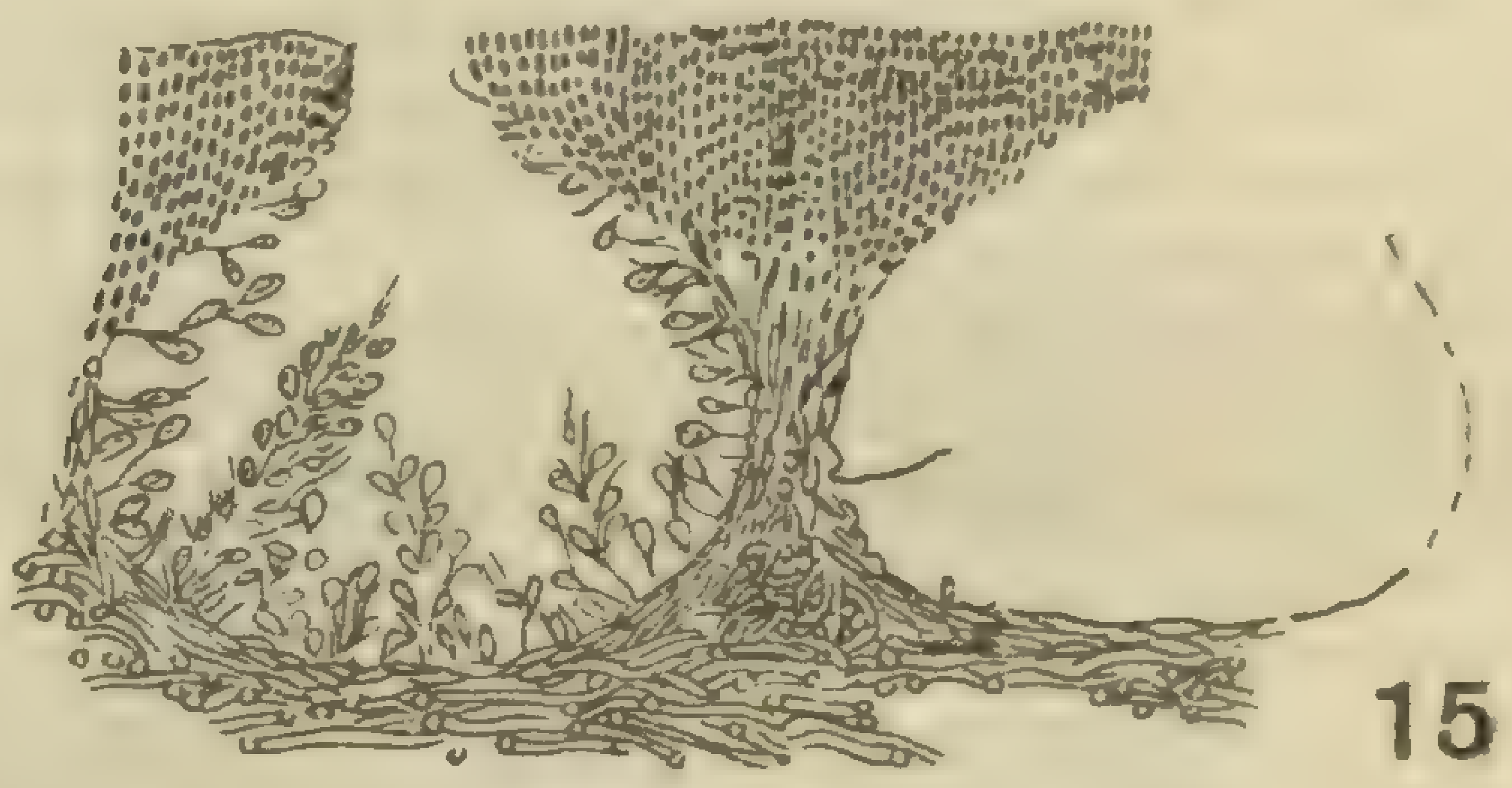

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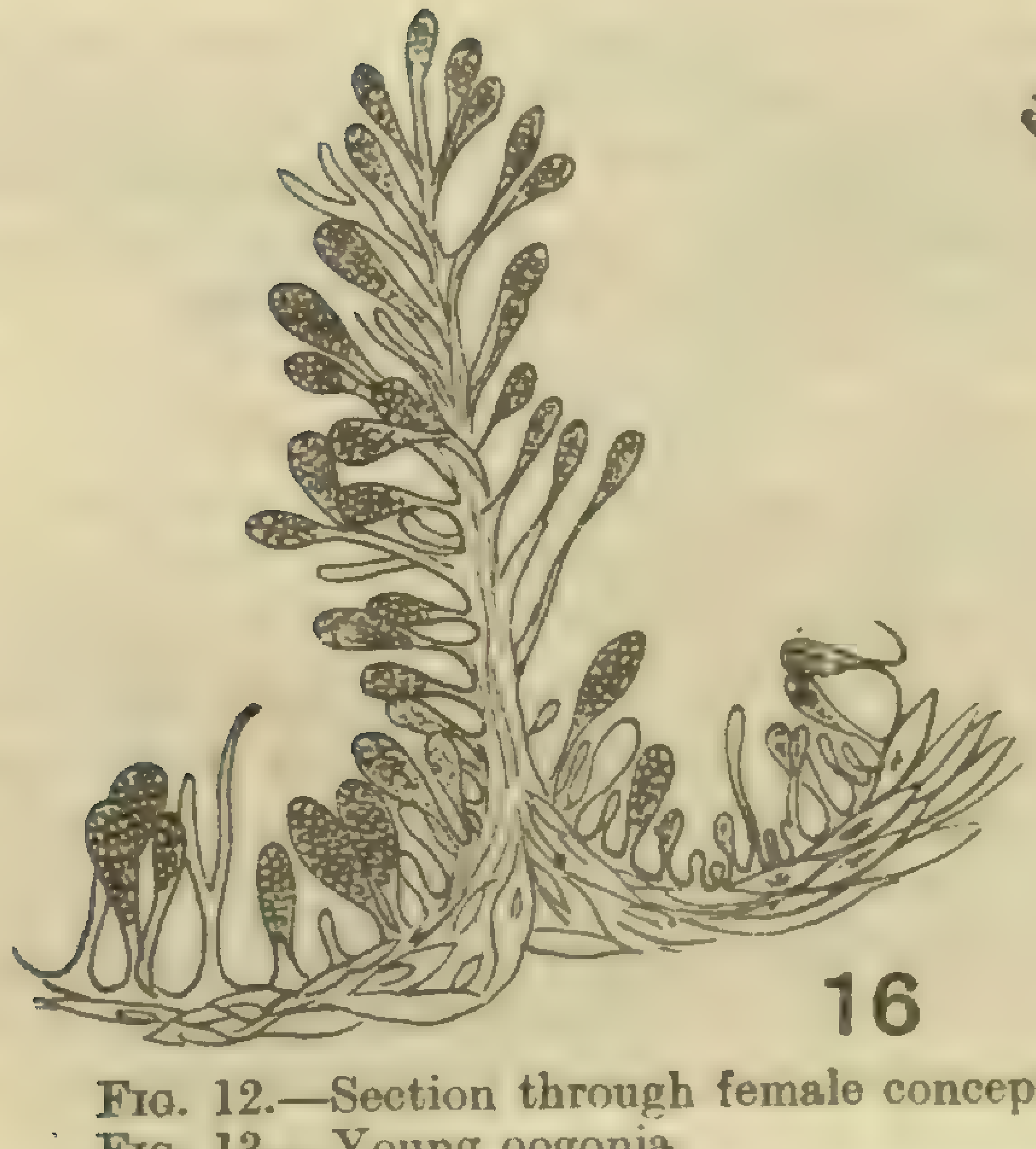

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FIG. 12.—Section through female conceptacle.
FIG. 13.—Young oogonia.
FIG. 14.—Older oogonia.
FIG. 15.—Section through male conceptacle.
FIG. 16.—Branched hair bearing antheridia.
FIG. 17.—Transverse section of stipe, showing pit.
FIG. 18.—Transverse section of stipe, showing pit (Bounty Island specimen).

that the reproductive organs may be found at any time of the year, though best in the winter months. In specimens collected at the end of March both ripe and immature oogonia were found, and also in others collected in September.

The male conceptacles (fig. 15) possess many more hairs, and they are much more branched, and more strongly developed. One hair (fig. 15) arising just opposite the ostiole extended almost to the ostiole itself, and was densely covered with branches, which were also branched, thus presenting the appearance of a small tree with monopodial branching.

The antheridia are formed usually on branched hairs from the swollen ends of the branches. They are much smaller than the oogonia, and the protoplasm is rounded off into numerous small colourless spermatozoids. Occasionally small unbranched hairs develop directly into antheridia. The spermatozoids escape into the surrounding water, still enveloped in an inner mucilaginous coat, which is dissolved by the water, setting free the actively swimming spermatozoids.

The contents of both conceptacles are forced out at low tide, probably owing to the sudden release from pressure. In this they are aided by the mucilaginous character of the hairs, which swell up and expel the contents in mucilage. The fronds may be seen covered by little white and brown dots, over the ostioles of the conceptacles. These are the male and female organs cohering together in the mucilage. When the tide rises, the mucilage and walls surrounding the organs are dissolved, setting free the oospheres and spermatozoids. Each oosphere when set free becomes rounded off, and is surrounded by numerous spermatozoids carried to it by the water from a neighbouring male plant, and so fertilization of the oospheres takes place. It is noticeable that there is a great difference in the colour of the two plants, the one bearing oogonia being always darker than that which bears the antheridia, and when the reproductive organs are expelled from the mouth of the conceptacle the two may be recognized by the difference in colour of the small dots lying over the ostioles.

Peculiar Morphological Features.

External Markings.

On the stipe and lower part of the lamina are to be found curious markings, which seem to be cracks in the tissue. On the stipe these are usually seen on only one side, and are about 1·5 mm. in depth. The larger the stipe the greater the number of markings (fig. 1); but on quite small plants there are always at least two, just at the junction of the stipe with the holdfast. They are not cracks in the tissue, as was at first supposed. A section taken across one shows that the radial arrangement of the outer tissue of the stipe is continuous throughout (figs. 17 and 18). This formation is probably an adaptation of the plant to its environment. The plant, as before stated, grows in a horizontal position, and these pits are found usually on the upper surface, so that when the plant is left uncovered by the water, and the weight of its fronds are pulling the stipe downward, these pits are wide open, and afford the stipe a means of increasing its surface area, and in this way prevent it from being so easily snapped in two by the weight upon it. When the plant is covered with water it is again subjected to great strain from the constant dashing of the water upon it, and these pits give greater protective pliability to the stipe.

There are smaller linear markings on the lower expanded portion of the frond; these are more numerous, forming a very regular pattern.

The marks vary from about 3 mm. to 6·2 mm. in length, and on that portion of the frond nearest the stipe are arranged in broken concentric

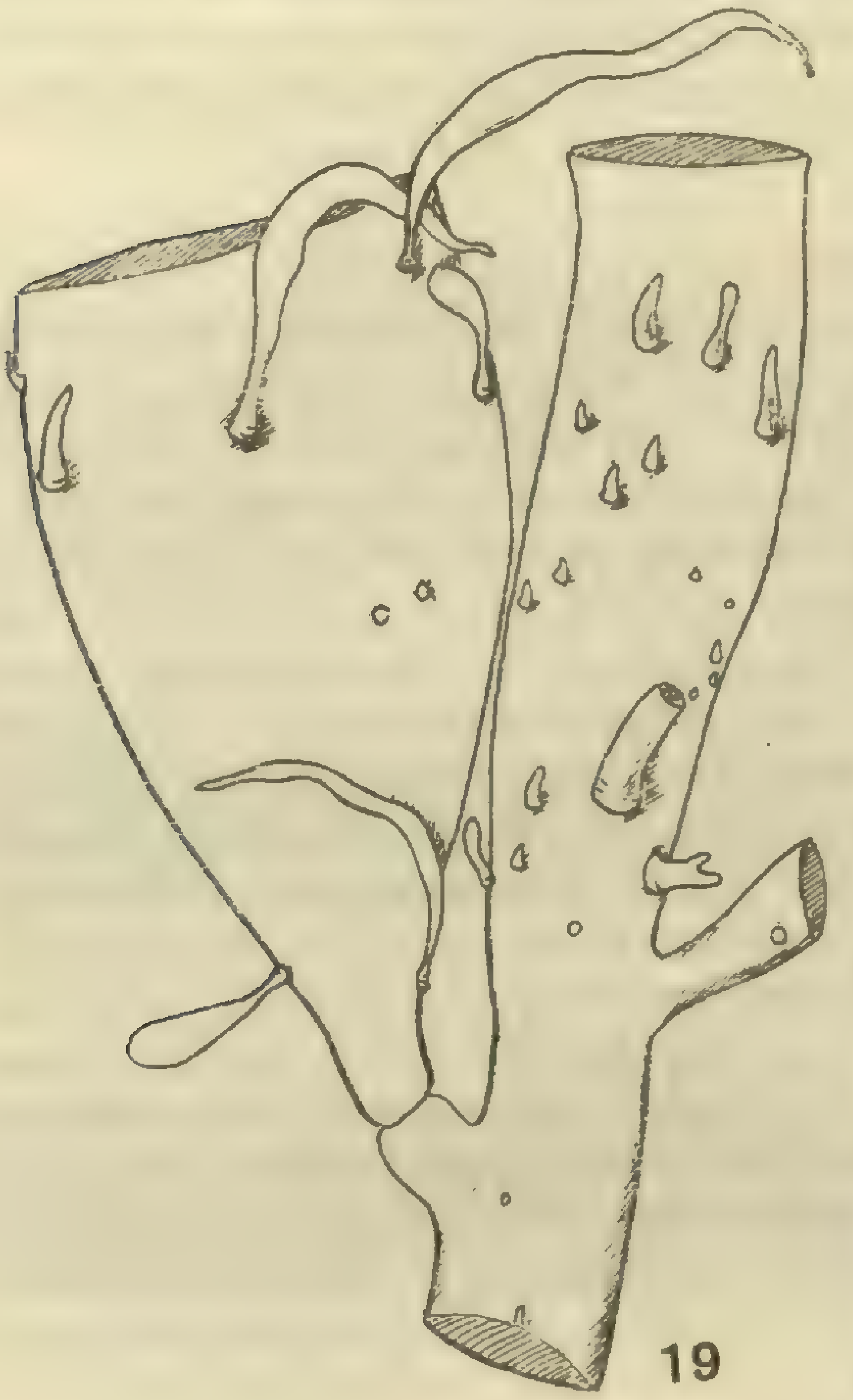

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FIG. 19.—Portion of stipe and lamina, showing "budding."
FIG. 20.—Section through bud and stipe, to show structure.
FIG 21.—Outline of specimen from Bounty Island.

rings (fig. 1). Farther from the stipe they are arranged somewhat diagonally across it, and finally disappear altogether where the frond

begins to be divided into finer segments. The markings are not deep enough to appear in a transverse section of the frond, but are plainly seen on surface view. They would serve the same purpose as the deeper pits of the stipe, to give greater pliability to this portion of the frond. In both cases they probably owe their origin to the continual mechanical stress on the tissue of the plant as it is growing.

Buds.

A plant collected in September, the beginning of the spring, presented a curious appearance owing to the presence of numerous "buds" occurring on all parts of stipe and lamina (fig. 19). This budding was not confined to the outer edge of the frond, but what appeared to be small plants in all stages of development were found scattered irregularly over its surface. The youngest plants appeared as small light-coloured round patches on the surface, interrupting the dark-brown colour of the frond; others were about 3 mm. in length, appearing as little conical protuberances; in others there was some differentiation into stipe and frond, the frond appearing as a flattened blade about the length of the stipe; in the largest the frond was about 7 mm. in length, and in one case it was branched. Wherever the stipe of these small plantlets was differentiated at all it showed the peculiar ring-like cracks in the tissue characteristic of the adult stipe of this species of the *Durvillea*. In the younger buds the meristematic tissue appeared to have arisen from the layers below the coloured tissue of the frond, and the buds had broken through these layers, which formed a ring of tissue round it. In the older buds this ring of tissue disappears, and the chlorophyllous tissue of the bud is continuous with that of the parent frond Under a high power of the microscope a section through one of these buds shows that the cells of the apex of the bud are irregular in shape, and rather small, like those of rapidly growing tissue (fig. 20), and they present an appearance quite different from the regular radial arrangements of the upper layers of the parent frond, resembling more in shape and appearance the cells of the very young plants described below; no special apical cell could be observed.

From this it would seem that the frond and stipe have an unlimited power of growth in any direction; any cell, apparently, of the outer tissue may become meristematic, take upon itself the functions of an apical cell, and form the starting-point for fresh growth. In these lower forms of plant-life, even though the plant may attain an enormous size, as in the case of *D. antarctica*, there is not much differentiation amongst the cells, and it is not unusual to find a cell becoming meristematic in this way. It is, however, the first time the peculiarity has been noticed in *Durvillea*. It may be that at this time of the year (September) fresh growth is incited amongst these lower forms, and finds an outlet in this way. It is possible that the cells of the holdfast may become meristematic and give rise to the young plantlets which have been observed attached to an old holdfast.

Bounty Island Specimen.

A specimen collected at Bounty Island by Dr. Cockayne presented some very striking points of contrast with the specimens from this coast.

(1.) The colour was a very much lighter yellow, and Dr. Cockayne says that the lighter colour is quite distinctive of the *Durvillea* found on

Bounty Island. The island consists of a few rocks, almost destitute of vegetation, and this seaweed forms a fringe round it, exposed to most tremendous seas. The *Durvillea* seen on the other subantarctic islands of New Zealand was the ordinary dark-brown *D. antarctica*.

(2.) The frond was peculiarly branched; instead of ending in blunt segments, which may measure as much as 4 cm. across in this plant, the segments were divided up into a number of very fine filaments, which gave a peculiar tasselated appearance to the plant (fig. 21).

On only one portion of the frond were there any indications of air-chambers; the central tissue was just beginning to break down. On this portion were conceptacles filled with branched hairs bearing antheridia. The structure of these conceptacles agreed quite well with that of those of the ordinary form.

The cracks on the stipe were much deeper and usually wider than in the more common form, while the markings on the frond were continued up the main segments and were lost only on the finer divisions.

According to Dr. Cockayne, Bounty Island is subjected to very violent storms, and one would naturally expect a form which managed to maintain an existence under these conditions to show some modifications in its structure. These are found in this case in the finer filamentous segments of the frond, and in the pits and markings, which enable the plant to withstand a great strain. This plant, then, marks an extreme *D. antarctica* tendency, and may be considered as a variety of that species, which has developed in a manner exactly opposite to *D. Harveyi*. Further specimens of this form should be obtained and compared with Areschoug's specimens from South America.

Young Plants.

A peculiar case of the growth of the young plants was noticed in the month of September, where four young plants varying from 25 mm. to 50 mm. in length were found growing on a large holdfast which still bore the adult plant. The smallest of these plants was differentiated into stipe and lamina, the lamina being dichotomously branched at its apex. The stipe also showed clearly at the base one or two of the characteristic pits. The portion of the holdfast to which they were attached was different from the rest of the tissue. It appeared to form a layer about 3 mm. in thickness over a mass of harder and more compact tissue, evidently the original holdfast of the large plant. This layer was soft, and could easily be cut away from the harder tissue below. A ring of a slightly darker colour could be discerned, separating a portion of the holdfast round each plant, which fact would lend support to the theory that the holdfasts of the different plants, though originally separate, may in course of time coalesce. From all appearances it would seem as though in this case the ripe egg had fallen on to the old holdfast and germinated there, and so saved itself the trouble of forming an entirely new holdfast by making use of the old one, and possibly adding a fresh layer on its surface.

On cutting a section through the holdfast vertical to the surface at the base of this young plant, a cylinder of darker colour appeared to be sunk into and differentiated from the surrounding tissue, thus suggesting that the young plant might possibly have anchored itself on the old holdfast by sending down an organ resembling the haustoria of the parasitic phanerogams, but under the microscope the tissue appeared to be homogeneous throughout.

Conclusion.

The study of the anatomy of *Durvillea antarctica* shows that there is not much differentiation of tissue in the three regions, the tissues of one passing gradually into those of the other. There is no special conducting tissue, as in *Macrocystis;* the meristematic tissue of the holdfast is perhaps worthy of mention. Oltmann considers this plant one of the lowest of the fucoids, and this is borne out by the results attained in the present study.

The peculiar pits on the stipe and the markings on the lamina are interesting in the relation they probably bear to the conditions under which the plant lives. In this connection also the study of the Bounty Island form should throw further light on the problem of the variation of the plant in response to external stimuli.

The study of large seaweeds such as this is interesting in connection with Church's theory of the origin of land-plants (1919). Here are found the three regions of the plant-body corresponding to the root, stem, and leaves of higher plants, which his theory demands; but, on the other hand, there is no trace of a "basal absorptive mechanism" nor sign of an upward conductive axial tissue which would be necessary if *Durvillea* were to lead on to anything higher in the scale of plant-forms.

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ART. 39.—*New Species of Flowering-plants.*

By T. F. CHEESEMAN, F.L.S., F.Z.S., F.N.Z.Inst., Curator of the Auckland Museum.

[*Read before the Auckland Institute, 19th December, 1921; received by Editor, 31st December, 1921; issued separately, 22nd May, 1923.*]

1. **Astelia Cockaynei** Cheesem. n. sp. (*A. montana* Cockayne in *Bot. Surv. Tongariro Nat. Park* (1908), 36, *non A. montana* Seem., *Fl. Vit.* (1865–73), 313, t. 95.)

Affinis *A. nervosae* Banks et Soland. sed multo minore, foliis rigidis et utrinque sericeiis vel villosis, scapis folio brevioribus paucifloris.

Very closely allied to *A. nervosa*, and possibly only a subalpine state, but smaller in all its parts, and with the foliage much more rigid and silky. Leaves numerous, 2 ft. 6 in. long or even more, 1⅓–1½ in. broad, linear or linear-ensiform, gradually narrowed into long acuminate points, dilated at the sheathing base; midrib stout, prominent beneath; half-way beneath the midrib and the margin is a stout rib composed of 2 almost coalescent veins; ribs often coloured red or purplish-red; upper surface of leaf usually with a thin easily-detached silvery pellicle and generally more or less clothed with silky appressed hairs, sometimes almost villous; under-surface paler, more or less scurfy, generally covered with white appressed scales or hairs, which are most plentiful along the margins; veins numerous, evident; sheathing base of leaves densely covered with long appressed silvery-white or tawny hairs. Flowers very similar to those of *A. nervosa*, but the panicles much smaller and with fewer branches, and the females much more compact. Berry ovoid or ovoid-globose, pointed at the tip, ⅓ in. diam., fleshy, reddish-orange, enclosed in the persistent cup-shaped enlarged base of the perianth, which is often but not invariably coloured red within. Seeds 2–3 in each cell, black, angled.—*A. nervosa* var. *montana* T. Kirk in Cheesem. *Man. N.Z. Fl.* (1906), 714.

Hab.—North and South Islands, Stewart Island: Abundant in subalpine localities from Hikurangi, Mount Egmont, and Taupo southwards. 2,500–4,500 ft.

There can be little doubt that a direct passage can be traced from *A. Cockaynei* into *A. nervosa*. On the mountains of north-west Nelson I have several times satisfied myself on this point; and Mr. Petrie has come to the same conclusion as regards the Tararua Mountains (*Trans. N.Z. Inst.*, vol. 40 (1908), 293–294). But the difference between the extreme states of *A. Cockaynei*, with its comparatively low tufts of greyish-white foliage almost shaggy from the abundance of silky hairs, and the highly developed form of *A. nervosa* formerly known as *A. grandis*, in which the leaves are almost glabrous, and sometimes reach a height of 8 ft., with a width of over 4 in., is so pronounced that I cannot refuse to draw a line of division between the two plants.

2. **Nasturtium Gibbsii** Cheesem. n. sp.

Species habitu *N. latesiliqua* sed graciliore et undique glabro, foliis multo angustioribus ad apicem paucis dentibus instructis.

Very similar to *N. latesiliqua*, and, like it, with a stout woody rootstock as thick as the little finger. Radical leaves very numerous, but soon

withering when the plant flowers, spreading, 3–7 in. long, consisting of a narrow-linear blade $\frac{1}{8}$-$\frac{1}{5}$ in. broad or sometimes even less, from which towards the top project 1–3 pairs of spreading or erecto-patent teeth $\frac{1}{8}$ in. long, more or less coriaceous, smooth and glabrous, or sometimes furnished with a few long hairs on the margins of the leaves. Cauline leaves similar to the radical, the lower ones broader. Flowering-stems one or several, 6–24 in. high, branched, glabrous, the branches usually spreading. Flowers very numerous, $\frac{1}{4}$ in. diam., white. Petals spathulate, with very long claws. Pods large, $1\frac{1}{2}$–3 in. long, strongly curved, turgid. Seeds numerous, compressed, reddish-brown, pointed at the tip.

Hab.—South Island: Nelson—Ravines on the face of Mount Lockett, alt. 3,500 ft.; *F. G. Gibbs!*

Although closely allied to *N. latesiliqua*, this differs in a marked manner in the taller and more slender glabrous habit, and particularly in the more numerous exceedingly narrow glabrous leaves, which are almost entire except for a few distant projecting teeth towards the top of the leaf.

3. **Pomaderris rugosa** Cheesem. n. sp.

Affinis *P. Edgerleyi* Hook. f. sed differt caulibus altioribus, erectis et fastigiatis; foliis longioribus rugosis, supra non scabridis.

An erect branching shrub 4–8 ft. high or more; bark dark brown or dark purplish-brown; branchlets villous with stellate or simple hairs. Leaves elliptic-lanceolate or oblong-lanceolate, $\frac{1}{2}$-$1\frac{1}{2}$ in. long, obtuse or subacute, much wrinkled and glabrous above with the veins deeply impressed; the veins prominent beneath and densely covered with ferruginous stellate hairs, the interspaces between the veins covered with longer and paler simple hairs mixed with a few stellate ones. Flowers very numerous, in terminal and axillary cymes, small, $\frac{1}{10}$ in. diam. Petals wanting. Calyx-tube densely hoary with flexuous silky hairs. Styles divided nearly to the base. Ripe cocci not seen.—*P. Edgerleyi* Cheesem., *Man. N.Z. Fl.* (1906), 100, and *Ill. N.Z. Fl.*, i (1914), t. 28 (*but not of Hook. f.*).

Hab.—North Island: Whangarei Heads, summit of Mount Manaia, *T. Kirk! T. F. C.*; Cape Colville and Coromandel southwards almost to the Thames, upper part of the Kauaeranga Valley, Thames, *T. F. C.*, *Adams! Townson!* Mercury Bay, *T. Kirk!*

So far this has been confused with *P. Edgerleyi*, from which, however, it can be readily distinguished by its much taller and more fastigiate habit, and by the longer and narrower leaves, which are quite glabrous on the upper surface; whereas those of the true *P. Edgerleyi* have the upper surface densely covered with short stiff bristles. Both species are included in the description of *P. Edgerleyi* given in the *Handbook*, but in the original notice given in the *Flora of New Zealand* (vol. 1, p. 46) Hooker specially mentions the "scabrid" leaves in his account of Edgerley's plant, thus fixing the application of the name.

4. *Note upon* **Epilobium junceum** Solander.

New Zealand botanists have had much difficulty in deciding which species of *Epilobium* was entitled to bear Solander's name of *junceum*. The facts are as follows: *E. junceum* was discovered by Banks and Solander at Te Oneroa, the locality where the present town of Gisborne now stands, and was gathered by them in almost every locality visited during Cook's first voyage. A description of it was prepared by Solander for his manuscript *Flora of New Zealand*, a work which, as is well known, was never

actually issued. Forster also collected it during Cook's second voyage—probably at Queen Charlotte Sound—and published it in his *Prodromus* under Solander's name—unfortunately without any description. Consequently, without access to the Banksian collection, the whole of which was lodged in the British Museum, it was practically impossible to be sure of the identity of the species. Hooker, when preparing the *Flora Novae Zelandiae*, examined the Banksian collection, and applied the name of *junceum* to a group of plants including *E. hirtigerum*, *E. erectum*, and *E. cinereum*, but did not associate the name "*junceum*" with any one of them. Hooker followed the same plan in the *Handbook*, and even Haussknecht, whose *Monograph* appeared in 1884, still treated "*junceum*" as the head of a number of varieties without particularizing any one to bear the name.

From the above it is quite clear that an examination of the Banksian types was absolutely necessary to determine the identity of the plant. Fortunately, through the liberality of Dr. Rendle, of the British Museum, I received a few years ago a fairly complete set of the plants collected by Banks and Solander during Cook's first voyage. On referring to the *Epilobia* I found two specimens labelled "*Epilobium junceum*." These are practically identical with *E. cinereum* A. Rich. In future, therefore, this plant must be treated as a synonym of *E. junceum* Sol.

It is worth mention that Solander divided his *junceum* into two varieties var. *a*, *campestre*, which answers to *E. cinereum* A. Rich., and var. *b*, *limosum*, which the specimens prove to be *E. hirtigerum* A. Cunn.

As it may be a convenience to New Zealand botanists to have a description of the plant which, if the preceding remarks are accepted, must be regarded as Solander's *E. junceum*, I reproduce here a copy of that which will appear in the forthcoming edition of the *Manual of the New Zealand Flora*:—

"*E. junceum* Soland. in *Forst. f. Prodr. Append.* (1786), n. 516, *nomen nudum*.—Stems strict and erect from a hard almost woody decumbent base, 6–18 in. high or more, slender, terete, leafy, simple or branched, sometimes excessively so, more or less covered with fine greyish-white pubescence, sometimes almost glabrate towards the base. Leaves often crowded on short axillary branchlets, variable in size, $\frac{1}{2}$–$1\frac{1}{2}$ in. long, sessile, oblong-lanceolate to linear-lanceolate or linear-spathulate, sub-opposite at the base, alternate above, abruptly mucronulate at the apex, margins furnished with distantly placed denticles, both surfaces more or less clothed with fine ashy pubescence, rarely almost glabrous. Inflorescence leafy, towards the top of the stems. Flowers small, pale rose, $\frac{1}{4}$ in. long. Calyx-segments linear-lanceolate, acute, ashy-pubescent. Capsule long, slender, erect, straight or curved, 2–3 in. long, tapering upwards into a short truncate style; peduncle short, seldom exceeding the leaves. Seeds oblong-obovoid, papillose.—Spreng., *Syst.*, ii (1825), 233; A. Cunn. *Precur.* (1839), n. 551; Raoul, *Choix* (1846), 49; Hook. f., *Fl. Nov. Zel.*, i (1853), 60, *in part*; *Handb. N.Z. Fl.* (1864), 80, *in part*; Haussk., *Monog. Epilob.* (1884), 289, *in part*; T. Kirk, *Students' Fl.* (1899), 169, *in part*; Cheesem., *Man. N.Z. Fl.* (1906), 174, *in part*. *E. cinereum*, A. Rich., *Fl. Nouv. Zél.* (1832), 330; A. Cunn., *Precur.* (1839), n. 544. *E. incanum*, *virgatum*, and *confertum*, A. Cunn., *l.c.*, nn. 545, 547, 549.

"North and South Islands, Stewart Island: Abundant in lowland districts throughout, especially in the northern part of the North Island, but not common in the elevated districts of either the North Island or South Island. Sea-level to 2,000 ft. November–March."

5. **Nothopanax laetum** Cheesem. n. sp.

Affinis *N. arboreo* Seem., sed foliis longioribus et multo coriaceis, 25–35 cm. longis; petiolo et nervo medio purpureo; marginibus minute sinuatis-serratis.

A small much-branched tree or large round-topped shrub 8–20 ft. high, with much of the habit and appearance of *N. arboreum*. Leaves much larger and more coriaceous, digitately 5–7-foliolate, primary petioles sheathing at the base, stout, dark purple, 5–8 in. long or more; leaflets 6–12 in. including the petiolule, narrow obovate-oblong, acute or subacute, gradually tapering to the base, petiolules and midribs conspicuously dark purplish-red, dark green and glossy above, paler beneath, margins surrounded by a faint purplish line, upper two-thirds shallowly sinuate-serrate or dentate, lower third entire, often unequal at the base. Inflorescence composed of large terminal compound dioecious umbels, very similar to that of *N. arboreum*.

Hab.—North Island: Auckland—Hills in the upper valley of the Kauaeranga River, Thames, alt. 1,000 ft., *T. Kirk! T. F. C., W. Townson!* Taranaki—Upper Waitotara, *J. R. Annabell!*

This differs altogether from *N. arboreum* in the much larger and more coriaceous leaves, which are often 1 ft. in length and have dark purplish-red petioles and midribs; and, according to Mr. Townson, in the laxly drooping position of the leaves, and more finely-cut serratures.

6. **Aciphylla divisa** Cheesem. n. sp.

Species ex affinitate *A. Monroi* Hook. f. a qua differt caule robusto, foliis majoribus profuse bipinnatis, segmentis latoribus magis coriaceis.

Stems 6–18 in. high, densely clothed below with the remains of the old leaves, smooth and shining, perfectly glabrous in all its parts. Leaves very numerous, variable in size, 4–15 in. in total length; lamina 2–4 in. broad, obovate or obovate-cuneate when spread out, 3-pinnatisect; primary divisions 4–5 pairs, suberect, closely placed, often overlapping; ultimate segments linear, $\frac{1}{2}-1\frac{1}{2}$ in. long $\frac{1}{10}-\frac{1}{8}$ in. broad, rigid and coriaceous, gradually tapering into an acuminate pungent point, jointed at the base, striate, midrib canaliculate; margins thickened. Petiole as long as the lamina, stout, smooth and convex on the back, deeply concave in front. Sheaths equalling the petiole in length, much expanded and membranous at the base, deeply grooved, narrowed towards the top, and produced on each side into a long slender spine. Flowering-stem exceeding the leaves, tall, stout, often $\frac{1}{3}$ in. diam. or more, grooved, naked. Male and female inflorescence much alike in size and shape, forming a globose head 2–4 in. diam. Lower bracts often forming a kind of involucel at the base of the panicle; sheaths large, broad and membranous, tipped with 3 long subulate spines. Peduncles of the male umbels $\frac{1}{2}$–2 in. long, females about half the length; rays numerous, spreading, slender; involucral bracts linear. Fruit $\frac{1}{8}$ in. long, linear-oblong, carpels equally 5-winged, or one 5-winged and the other 4-winged.—*A. Monroi* var. *divisa* Cheesem. in *Trans. N.Z. Inst.*, vol. 47 (1915), 40.

Hab.—South Island: Probably not uncommon in the higher mountain districts of Canterbury and Otago. Mount Cook district, abundant on the mountains flanking the Hooker and Tasman Valleys, *T. F. C., Cockayne! Petrie! Wall!* Otago—Mountains near Lake Wakatipu, *J. Speden! W. A. Thomson!* Garvie Mountains, *D. L. Poppelwell!* Mount Bonpland, *Petrie;* mountains above Lake Harris, *Cockayne!* 3,500–5,500 ft. December–February.

In my "Notes on *Aciphylla*" (*Trans. N.Z. Inst.*, vol. 47, p. 42) I treated this as a variety of *A. Monroi.* But further study of the genus has convinced me that the differences between it and the original type of the species (which I have figured in the *Illustrations of the N.Z. Flora*) are far too great to allow such a course to be taken. The many plants included by Hooker in the *Handbook* under the name "*Monroi*" are, in my opinion, best treated as follows: —1. Leaves simply pinnate: *A. similis.* 2. Leaves sparingly bipinnate at the base: *A. Monroi* (type of the species). 3. Leaves 3-pinnatisect; ultimate segments linear: *A. divisa.* 4. Leaves pinnatisect, ultimate segments almost filiform: *A. multisecta.*

ART. 40.—*Descriptions of New Native Flowering-plants.*

By D. PETRIE, M.A., Ph.D., F.N.Z.Inst.

[*Read before the Auckland Institute, 19th December, 1921; received by Editor, 31st December, 1921; issued separately, 22nd May, 1923.*]

1. Colobanthus Wallii sp. nov.

C. parvus dense ramosus, glaberrimus, ± 2·5 cm. altus. Folia dense imbricata, lineari-subulata, 5 mm. longa ± 1 mm. lata, plana v. apicem versus ± concava, enervia, basi expansa ac ± scariosa. Flores axillares sessiles v. subsessiles tetrameri, sepalis folia subaequantibus et latitudine aliquanto excedentibus, obtusis v. subacutis tenuibus, a marginibus ± scariosis ac pellucidis. Capsula sepalis ± dimidio brevior; seminibus late claviformibus.

A small tufted shortly and compactly branched species, ± 1⅛ in. high, perfectly glabrous. Leaves densely imbricating, erect or nearly so, linear-subulate, acute and shortly apiculate, ± $\frac{1}{5}$ in. long ± $\frac{1}{20}$ in. broad, flat or the upper part more or less concave, nerveless, pale along the edges, expanded and more or less scarious at their bases, texture soft. Flowers tetramerous, axillary, sessile or nearly so; sepals about as long as the leaves but considerably wider, obtuse or subacute, rather thin with broad semi-scarious pellucid margins. Capsule about half as long as the sepals; seeds broadly club-shaped.

Hab.—Crevices in limestone rocks at the top of Mount Arthur, west Nelson: Arnold Wall!

I have seen but a single plant of this: the size of the plant and its habit of growth may prove different in more favourable situations.

2. Epilobium Wilsoni sp. nov.

Caules a radice summa complures, 20–32 cm. longi, graciles teretes simplices v. parce divisi, a parte superiore sparse ac aeque pubescentes, rubri. Folia subpatentia, breviter petiolata, opposita v. apicem versus alterna, oblongo-lanceolata v. oblongo-ovata, tenuia, ± puberula, remote ac obscure sinuato-dentata, 2–3·5 cm. longa ± 1 cm. lata. Flores pauci ex foliorum superiorum axillis editi, majusculi ad 1·5 cm. longi, albi, pedunculi pergraciles, maturi bracteas subduplo superantes. Petala calyce duplo longiora, late obcordata. Capsula 20–34 mm. longa, gracilis sparse ac aeque pubescens. Semina papillosa, supra angustata, hoc latere plano illo subacute rotundato.

Stems several from the top of the root, 9–12 in. long, simple or sparingly branched, decumbent at the base, erect or ascending above, slender terete, bifariously pubescent or almost glabrous below, more or less evenly pubescent above, dark red. Leaves ½–1 in. long including the petiole, ¼–⅓ in. broad, shortly petiolate, all opposite or the uppermost alternate, spreading, oblong-lanceolate to oblong-ovate, usually obtuse at the tip, thin and membranous, faintly puberulous or nearly glabrous, faintly and remotely sinuate-dentate, midrib and veins usually evident. Flowers not very numerous, springing from the axils of the uppermost leaves, large, ¼–½ in. in diameter, apparently white. Calyx-segments linear-lanceolate, acute thin and glabrous. Petals twice as long as the calyx, broadly obcordate. Mature peduncles ½–¾ in. long, slender, sparsely but evenly pubescent. Capsules ¾–1¼ in. long, slender, sparsely but evenly pubescent. Seeds papillose, narrowed upwards, one side almost flat, the other distinctly ridged.

Hab.—Isolated Hill, Clarence Valley: B. C. Aston! Swale River, Clarence Valley (Marlborough): Aston and Wilson!

Through Mr. Cheeseman's courtesy I have here reproduced the description which he has prepared for the new edition of his *Manual.* The affinitis of this species are far from obvious. In the size of the flowers it recalls *E. chloraefolium* Haussk., but is in other respects widely different. The form of the seeds is very characteristic. It is named in honour of Major Robert A. Wilson, D.S.O., who greatly assisted Mr. Aston in the exploration of the vegetation of the Clarence Valley.

3. **Carex Enysii** sp. nov.

Carex *C. aciculari* (Boott) affinis; differt habitu perlate diffuso denseque caespitoso; foliis brevioribus glaberrimis, spiculis paucifloris (masculis ad 2, foemineis ad 3); utriculis anguste ellipticis subteretibus, vix stipitatis, apice nec elongatis nec serratis, ore integris v. perobscure bifidis.

A very short slender species forming a wide-spreading dense turf in moist places. Culms up to 3 cm. long, stiff, erect, filiform, terete, little grooved. Leaves as long as the culms, erect or ascending, subterete, filiform, perfectly glabrous, grooved on the front with broad sheathing bases and rather blunt tips. Spikelets small, solitary, terminal, 3 mm. long or less, few-flowered, female flowers (2–3) below, males (1 rarely 2) above. Glumes ovate-lanceolate, acute, brown with a green midrib, the lowermost produced into a slender bract-like elongation twice as long as the utricles or less. Utricles blackish-brown above, greenish below, glabrous, narrow-elliptic, not ribbed, not or scarcely stipitate, uniformly contracted upwards to the acute pale entire or obscurely bifid apex, almost terete but somewhat depressed on the inner face; style branches 3; nut trigonous.

Hab. — Craigieburn Range, North Canterbury Alps, *circa* 6,000 ft.: Arnold Wall!

Mr. J. D. Enys, to whose memory this species is dedicated, for a number of years occupied as a sheep-run the country where this plant occurs. He took a great interest in the botany of the district, and supplied to the late Mr. T. Kirk and others valuable specimens of rare and little-known plants.

4. **Carex Carsei** sp. nov.

Carex late diffusa caespitem densum ac continuum formans. Culmi numerosi, 8–12 cm. alti, graciles erecti leves obtuse triquetri, medio tenus

foliati. Folia culmos superantia, ± 3 mm. lata, graminea, plana v. ± complicata, in apices filiformes gradatim angustata, marginibus leviter scabridis. Spiculae 4–5; suprema mascula sessilis brevis pauciflora: ceterae omnino foemineae breves ovatae, quarum infima plerumque remota pedunculata, reliquae approximatae breviter pedunculatae v. sessiles; bractae longae foliaceae. Glumae ovatae acutae v. subacutae, pallide virides, tenues delicate pluri-nerviae. Utriculi 6–7 mm. longi, glumas subduplo superantes, anguste lanceolati, leves ± plano-convexi glabri, leviter plurinervii, apice acuminato bifidi; styli rami 3; nux obtuse triqueter.

A wide-spreading species forming a close continuous sward in swampy stations. Culms numerous, 8–12 cm. high, rather slender, stiffly erect, smooth striate, obtusely triquetrous (sometimes more or less compressed below), leafy to the middle. Leaves considerably longer than the culms, long-sheathing, grassy, ± 3 mm. wide, flat or more or less complicate, very gradually narrowed into filiform tips, margins finely scabrid. Spikelets 4–5, the uppermost male only, short, sessile, cylindrical, few-flowered; the others entirely female and broadly ovate, the lowermost generally remote and then rather long-pedunculate, the remaining two or three approximate, shortly peduncled, with the uppermost sessile; bracts long, leafy, considerably exceeding the inflorescence, the lowermost when remote long-sheathing. Glumes ovate, acute or subacute, thin, pale-green, faintly many-nerved; utricles 6–7 mm. long, about twice as long as the glumes, narrow-lanceolate, pale yellow, smooth plano-convex or nearly so, somewhat compressed, faintly many-nerved, bifid at the acuminate tips; style branches 3; nut obtusely triquetrous.

Hab.—Swampy stations on the Waimarino Plain: H. Carse and H. B. Matthews! Near Lake Tennyson (Southern Nelson): W. G. Morrison!

This is a remarkably distinct plant, not closely related to any other native species. It fills considerable areas of swamp with a close grass-like sward, and never forms isolated tufts or tussocks. Mr. Carse's specimens are in young flower; Mr. Morrison's in ripe fruit.

5. **Danthonia Raoulii** Hk. f. var. **teretifolia** var. nov.

Folia culmis multo breviora, infra subinvoluta supra paene filiformia; culmi graciles quam in forma typica breviores; panicula minor, ramis binatis v. solitariis parce scaberulis; spiculae minores ac angustiores; arista reflexa, basi hand torta.

Hab.—Mount Rochfort (near Westport), *circa* 3,000 ft.: Arnold Wall! Wet flats at the base of Mount William (near Denniston): D. Petrie.

6. **Poa Wallii** sp. nov.

Poa ± caespitans 4–10 cm. alta v. ultra; culmi pauci a basi ramosi, ± stoloniferi, glabri. Folia ± 2·5 cm. longa, linearia acuta plana v. ± complicata, vaginas subaequantia; caulinorum vaginis elongatis saepe ad paniculae basim pertinentibus; ligula lata brevis ± erosa, aliquando paene obsoleta. Panicula parva, anguste ovata, ramis capillaribus glaberrimis 1–3-floris, inferioribus binatis superioribus solitariis; spiculae plerumque paucae, anguste lanceolato-ellipticae, acutae, 5–6 mm. longae 2 mm. latae, 3 (raro 4) flores gerenetes: glumae vacuae leviter inaequales acutae 3-nerviae, florigerae ovato-lanceolatae acutae purpureo-virides, 5-nerviae (nervo medio solo ad apicem pertinente), carina ± scabridae, a tergo ac basi pilorum longius culorum flocco subamplo vestitae, apicibus scariosis. Palea glumis florigeris aequilonga, apice breviter bifida, nervis ciliatis.

A rather short sparsely-tufted grass, 4 in. high or less, but occasionally somewhat taller. Stems few, branching from the base and more or less stoloniferous; leaves ± 1 in. (2·5 cm.) long, about equalling their broad thin scarious sheaths, narrow-linear, flat or more or less complicate, faintly striate, cauline with shorter blades and longer sheaths (in smaller specimen usually reaching to the base of the panicle); ligule broad, short, more or less erose, sometimes almost obsolete. Panicle narrow-ovate, branches short, capillary, glabrous, few-flowered, the lower binate, the upper solitary; spikelets purplish-green, 5–6 mm. long ± 2 mm. broad, of 3 (rarely 4) florets, narrow lanceolate-elliptic, acute; empty glumes slightly unequal (the upper longer and reaching half-way up the spikelet), ovate-lanceolate, acute, 3-nerved; flowering-glumes ovate-lanceolate, acute, 5-nerved (the median nerve alone reaching to the apex), delicately scabrid along the keel, with a tuft of long hairs at the back and the base, scarious at the edges and especially at the tips; palea nearly as long as its glume, ciliate along the nerves and shortly bifid at the tip.

Hab.—Top of the Craigieburn Range, Canterbury Alps, *circa* 6,000 ft.: Arnold Wall! I have seen a few taller pieces of what seems to be the same grass collected by Mr. W. G. Morrison at the headwaters of the Waiau River, Amuri County: these pieces were long past flower.

Art. 41.—*Notes on* Pittosporum obcordatum.

By G. O. K. Sainsbury.

Communicated by T. F. Cheeseman.

[*Read before the Auckland Institute, 19th December, 1921; received by Editor, 21st December, 1921; issued separately, 22nd May, 1923.*]

This shrub has been reported from only three localities, all in New Zealand. It was originally discovered by Raoul at Akaroa in 1840 or 1842, and, in spite of persistent search for it in that district, has never been found there again. After a lapse of many years, however, it was unexpectedly rediscovered by the late Mr. R. H. Matthews at the outlet of Lake Tongonge, near Kaitaia, in 1901, and again by myself at Wairoa, northern Hawke's Bay, in 1920. This last finding is of interest, since it occurred in an intermediate locality, the plant up till now having been chiefly remarkable as a striking example of discontinuous distribution. So extreme was the case considered that it was suggested that Raoul, who also collected at the Bay of Islands, had made a mistake in the habitat of the plant, wrongly ascribing it to Akaroa. This view was combated by Mr. T. F. Cheeseman (*Trans. N.Z. Inst.*, vol. 39, p. 435), who drew attention to the fact that the flowering-period was mentioned by Raoul as December, whereas Mr. Matthews's observations of the Kaitaia plant showed that it flowered from the middle of October to the first week in November. The flowering-period of the Wairoa plant was, last spring, for about three weeks after the middle of October, the same as that of the Kaitaia plant; and this fact, together with that of its discovery in an intermediate locality, would indicate that Raoul was not mistaken in the habitat. The locality where it was collected in the Wairoa district is a small portion of swampy

forest situated in the Wairoa River flats, about half a mile from the river's western bank: it is now reserved, and appears to be the remnant of a larger area.

Pittosporum obcordatum appears to be exclusively a swamp plant, as it has never been found in a hilly or dry locality. The trees with which it is associated in the Wairoa habitat consist principally of *Podocarpus dacrydioides* and *Hoheria populnea* var. *angustifolia*: whilst the undergrowth, which is all of a twiggy, divaricating type, includes *Coprosma propinqua* and *C. rigida*, *Myrsine divaricata*, *Myrtus obcordata*, *Melicytus micranthus*, and *Melicope simplex*. The resemblance to *Myrsine divaricata* is extraordinarily close, and the two shrubs, when neither in flower nor fruit, are indistinguishable at a distance of a few paces.

Pittosporum obcordatum bears a heavy crop of flowers and seed-capsules, and its appearance is then sufficiently striking to prevent it being overlooked by any ordinarily careful observer. The fragrant flowers are of a light-saffron colour, and are often edged on both sides of the petals, at the junction of the claw and the limb, with a narrow reddish line. The shrub attains a height of about 9 ft. Mr. Cheeseman, who kindly identified the Wairoa plant for me, informs me that it differs from the Kaitaia plant in its smaller leaves and less dense pubescence on young leaves, calyces, and ovaries. I have found that the seeds germinate quickly and freely, the seedling plant appearing above ground about eight weeks after planting. The seed-leaves are three in number, rarely four, and are oblong-lanceolate in shape. The succeeding leaves have a very curious appearance, being from ½ in. to 1 in. long, in shape narrow-linear with a broad decurrent base, and with the tips slightly widened out into three more or less regular lobes. The upper surface of some of the earliest leaves appears to be covered with colourless cells which give the leaf a shining scaly appearance. My seedlings of last spring's planting are now some 6 in. high, and have produced only the linear type of leaf, which gives to the plant a very striking and characteristic look. Some of the mature shrubs bear reversion shoots on the lower branches, which show leaves intermediate in form between the linear and adult leaves. Mr. H. B. Matthews, who has raised plants from Kaitaia seed, informs me that the seed-leaves are four in number, and that the linear leaves are not produced. We have no information as to the shape of the juvenile leaves of the Akaroa plant.

The other species of the genus *Pittosporum* found by me in the Wairoa district are *P. tenuifolium*, *P. eugenioides*, *P. Ralphii*, and *P. cornifolium*, whilst *P. rigidum* has also been reported by the late Mr. Colenso. This list is probably not exhaustive. As all attempts to rediscover the plant at Akaroa have failed, Kaitaia and Wairoa remain at present the only known habitats. The portion of swampy forest mentioned above as its habitat in Wairoa contains, so far as I know, the only similar association of divaricating shrubs in the district. Other portions of swampy bush bearing a superficial resemblance to it have been visited by me, but a careful search has failed to reveal the plant under notice, or, indeed, the majority of those of divaricating habit with which it is associated. In view of the facts that the plant is fairly plentiful in the small portion of bush in which it was found, that it seeds profusely, and that the seeds germinate freely, it is somewhat surprising that it appears to be confined to the one locality. The explanation may be that in such a situation the seeds could only be distributed by birds, and that they are not relished by them.

Art. 42.—*Natural Self-fertilization of Wheat on a Large Scale.*

By F. W. Hilgendorf, M.A., D.Sc., F.N.Z.Inst.

[*Read before the Canterbury Philosophical Institute, 7th December, 1921; received by Editor, 20th December, 1921; issued separately, 22nd May, 1923.*]

The area devoted to selection of pure strains of wheats at Lincoln College covered, in 1920, about 22 acres. Among these were six plots each about half an acre in extent, occupied by three pure strains of the variety known in New Zealand as White Straw Tuscan, a wheat closely allied to or identical with the Bellevue de Talavera of Europe. It is an early-maturing variety, coming into flower and ripening about a fortnight before the other varieties commonly grown.

In January, 1921, when they were nearly ready to cut, the plots were gone through for the purpose of picking out accidental impurities, this work embracing the roguing of intruding varieties, and in addition the roguing of any intruding strains of the same variety. It was at this stage that the fact became obvious that these three strains, G2, F8, and F10, were no longer pure, but included many strains—so many that it was not only impossible to pick out all the impurities, but, in one case, to tell which was the strain intended to be occupying the plot. It was at first thought that this was the result of accidental admixture of strains during the preceding harvest, where some ten Tuscan strains were grown side by side in the same field. But reflection on the care with which the harvest had been conducted, and on the very large number of the impurities, caused a search to be made for other explanations of the mixture of strains.

It was recalled that before the preceding harvest—that is, in December, 1919—a severe frost had damaged the wheats in the plots, and that the Tuscans, owing to their earliness, were the only ones that suffered, the yield of the strains of this variety being reduced from an estimated 60 to an actual 25 bushels per acre. None of the other varieties was frosted, and there were no marked impurities in their offspring in the succeeding year. It was taken as an hypothesis that the frost of December, 1919, had been just severe enough to kill the anthers of certain of the florets, but to leave the ovaries uninjured, so that if those ovaries developed at all they would have to be cross-fertilized, and that chiefly with pollen from their own or neighbouring strains of Tuscan, this being the only variety freely in flower within a fortnight of the time of the frost.

There were three ways of testing this hypothesis:—

(1.) To examine the mixed strains and see if their differences were such as to suggest cross-pollination between two strains of the same variety. This examination supported the hypothesis. The differences were very slight, and often elusive; they depended largely upon differences in times of ripening, and were often difficult to distinguish from variations induced by external conditions. Unfortunately, all the supposed pollen parents were not available for comparison, a number of strains grown in 1919 having been rejected and so not grown in 1920.

(2.) If the crops of 1920 had been grown from cross-fertilized seed, then the crop would represent the F_1 of a breeding-scheme, and there should be only as many types as there were parents, and that only where the male carried some dominant, affecting the appearance of the ripening plant. As a matter of observation, there were apparently some six or eight types in each of the plots, which would agree with the expectation

of the hypothesis. But the seed from this crop should show extensive variation. If any particular head were an impurity all its seeds should produce like plants; if it were a cross-bred its seeds might be expected to produce plants varying *inter se.* This was tested by taking twenty-five heads of the most varying appearances from each of the three strains and growing them in head-to-row plots. At the time of writing,* these plots are just ripening, and it is apparent that the variants selected last year were of three different classes:—

(*a.*) Accidental impurities—in which all the plants of the row are alike but are not Tuscans of the type of the plot from which they were selected.

(*b.*) Variants due to differences in soil or situation—in which all the plants of a row are alike and belong to the strain from which they were selected.

(*c.*) Natural crosses—in which the plants in a row vary *inter se.* In most of the cases the crosses are with other types of Tuscan, but in three rows the cross is with another variety that was grown in the same field.

The following table shows the number of each class of variants selected from each of the three strains:—

Strain.	Impurities.	Non-congenital Variations.	Crosses.	Totals.
G2	3	2	20	25
F8	3	13	9	25
F10	2	10	11	25

It was the strain G2 which in the roguing of last harvest appeared most heterogeneous, and this is reflected in the large number of proved crosses. In strain F8 a small number of crosses appears, and large a number of the variants selected were due merely to external conditions. This is reflected in the rather remarkable fact that, of the twenty-five rows of this strain, twelve contained plants affected with loose smut (from one to five plants per row of fifty plants), while in the other two strains no single smutted plant appeared. None of the wheat was pickled before sowing. Thus strain F8 is a smut-liable one, and the inheritance of this character indicates that the heads selected were of one strain—*i.e.*, the differences were accidental—the conclusion independently reached by an examination of the rows.

(3.) The third method of testing the hypothesis was to attempt to repeat the conditions and see if the supposed results were again obtained. The minimum temperature on the grass at Lincoln on the night of the frost was known, and Mr. Skey, of the Magnetic Observatory at Christchurch, twelve miles away, was able to provide a thermogram of the air-temperature in a shade-box on the night in question. From these two data an estimate could be made of the varying temperatures and their duration to which the frosted wheat had been exposed. Tuscan wheat was grown in pots at Lincoln, and when near flowering was removed to the garden of the freezing-works at Islington, where the New Zealand Refrigerating Company had arranged to produce such temperatures as were desired, Mr. A. M. Wright, chief chemist, and Mr. Piper, chief engineer, undertaking personal supervision of the experiments. When the anthers in the

* The completion of the paper was delayed for some weeks to allow almost complete ripening of the wheats under observation.

earlier florets of any particular set of plants were ripe but not extruded, six pots, containing about eighteen wheat-heads, were removed to the cooling-chambers. Four different series of temperatures were tried, each on six pots of wheat, the last one being as follows: The external air was at 50° F., and the pots were placed in a chamber 60 ft. by 24 ft., with a temperature of 36° F. During a period of six hours the temperature was gradually lowered to 26° F., and held there for two and three-quarter hours. The plants were then immediately removed to the open air, whose temperature was 60° F. After three days the florets were opened, and it was found that in the eighteen heads examined 16 per cent. of the florets had the anthers killed and the ovaries apparently unharmed. The anthers were withdrawn down and around the ovary, so that at first they escaped observation altogether. The filaments were found to be shrivelled, and the pollen-grains were fluid. The stage of development of the anthers appeared to be of importance, because it was usually in the central floret of the spikelet that the injury had occurred. In the remaining 84 per cent. of the florets the anthers were apparently uninjured.

The other series of temperatures which did not lead to the killing of anthers and also left the ovaries uninjured were as follows:—

(*a*.) Reduce from 39° to 29° in six hours, hold at 29° for two and three-quarter hours, and then raise gradually to 39° during the course of one hour, and then to open air at 60°. Result—plants wholly uninjured, due doubtless to the gradual thawing. (*b*.) The same as above, but at all points 3° F. lower—*i.e.*, minimum at 26° F., gradual rise. Result—all plants uninjured. (*c*.) The same as above, but all temperatures 3° lower still—*i.e.*, minimum at 23° F.; but in this case all plants were removed suddenly from the minimum temperature to the open-air temperature at 60° F. Result—all plants killed, anthers and ovaries; and in the majority of cases the glumes as well.

It was as a result of the failure in these three cases—(*a*), (*b*), and (*c*)—that the final and fairly successful series of temperatures recorded in paragraph (3) above was selected.

In this final case the florets in which the anthers had been killed were marked on the glumes with Indian ink, and the plants placed in the middle of a plot of Velvet wheat, some of whose anthers were then extruded. The Velvet wheat is so named from a velvety covering of hairs on the glumes, a character which proves to be dominant. The grains in the frost-esmasculated florets have developed and are nearly ripe in 70 per cent. of cases, and it is clear that these must have been cross-fertilized, if not by the Velvet wheat, at least by different florets of their own heads. The seeds will be sown and the proportion of Velvet crosses recorded.

It is clear, then, that frost of a certain intensity can lead to the cross-fertilization of wheat on a large scale, and this is one cause of the occurrence of new varieties.

It may be that artificial crossing of wheats can be more rapidly carried out by killing the anthers by freezing than by the usual method, but this would need suitable cooling-apparatus. Where this is available the plan would be to freeze the plants to some temperature like that above described, then tie the heads in paper bags with heads of the variety designed for the male parent, which should have, if possible, some easily recognized dominant character. On sowing all the seeds that ripen, those that have been crossed will produce plants showing the dominant, and will be kept, while those that are selfed will not show the dominant character, and will be pulled out and rejected.

ART. 43.—*Studies in the New Zealand Hymenophyllaceae: Part I—The Distribution of the Species in Westland, and their Growth-forms.*

By the Rev. J. E. HOLLOWAY, D.Sc., F.N.Z.Inst., Hutton Memorial Medallist.

[*Read before the Philosophical Institute of Canterbury, 1st December, 1920; received by Editor, 5th December, 1921; issued separately, 8th June, 1923.*]

Plates 56–76.

ANALYSIS OF PAPER.

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INTRODUCTORY.

THE Hymenophyllaceae constitute one of the most interesting of modern fern families, by reason of the fact that the family as a whole shows adaptation to hygrophytic conditions combined with a remarkable ability on the part of many of the species to flourish in more or less xerophytic situations. In the present and following papers I propose to set out the results of my studies in the New Zealand members of the family, basing my account of the distribution and of the growth-forms of the species upon what I learned as to their occurrence in the wet district of Westland, and in Part II comparing with these facts the ecology of the family as I have learned it in the drier parts of New Zealand. In the second paper I shall also bring together those facts concerning the general distribution of the species throughout New Zealand generally, and in the outlying islands belonging to the New Zealand Biological Region, which are contained in various botanical papers in the volumes of the *Transactions of the New Zealand Institute* and in other publications.

Two noteworthy publications dealing with the filmy fern as a living plant are those of Giesenhagen (12) and Forrest Shreve (26). The former of these authors gives a general biological survey of the gametophyte, and more especially of the sporophyte generation, basing his account upon herbarium material. Amongst other species, he discusses seven which occur in New Zealand. Forrest Shreve's paper is the outcome of his studies on the Hymenophyllaceae of Jamaica in their natural habitat. He deals with the vertical and the regional distribution of the greater number of these species, and he describes a number of illuminating physiological experiments conducted by him with the purpose of ascertaining the exact relation of the species to the water-supply and their ability to withstand drying.

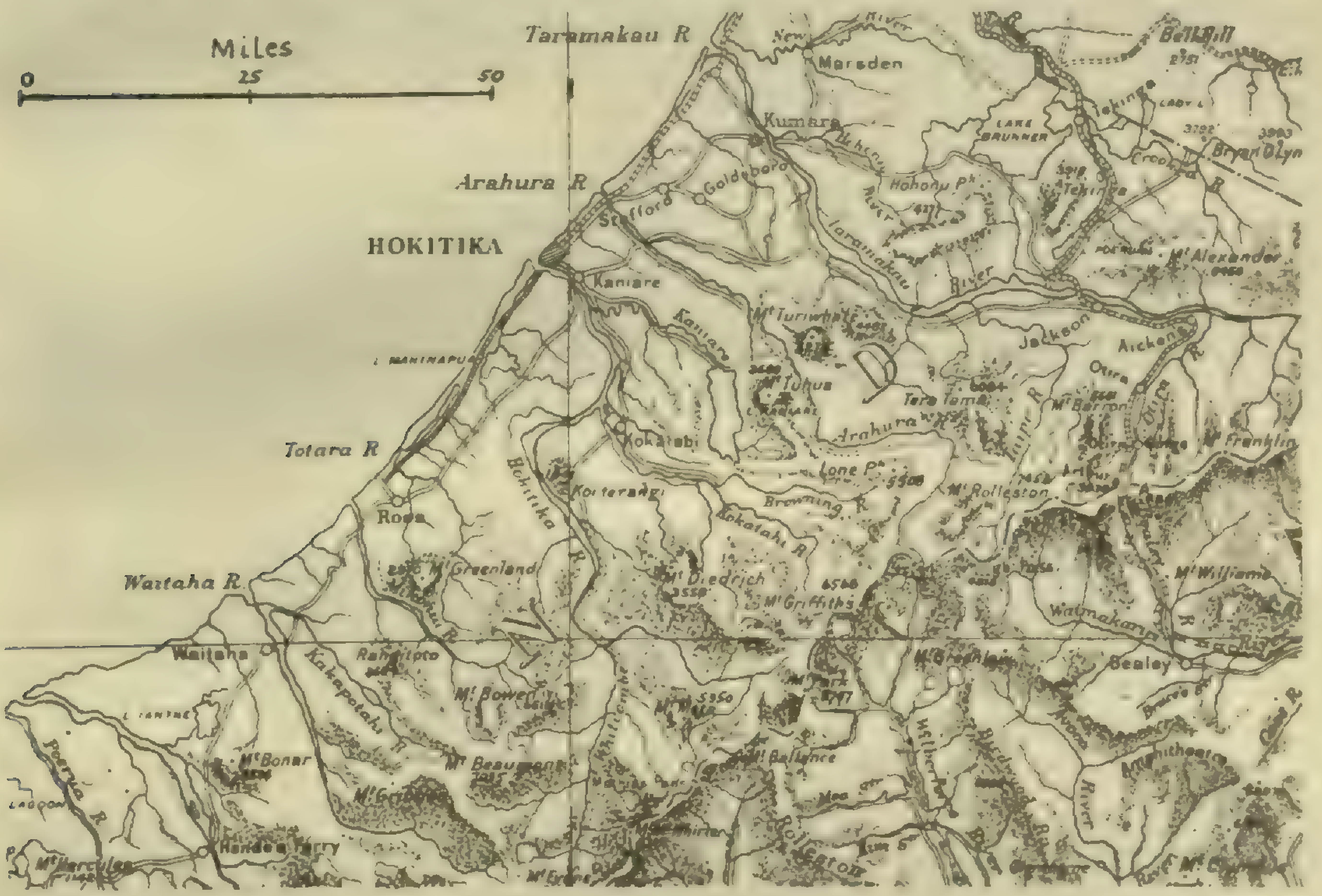
New Zealand is well known to be a special centre of distribution of the Hymenophyllaceae. In actual number of species this family constitutes one-fifth of the entire fern flora of this country, embracing twenty-seven species, of which twenty belong to the genus *Hymenophyllum* and seven to *Trichomanes*. In the heavy taxad forests of the western districts, and more especially of Westland in the South Island, where the proximity of the high mountain-ranges to the coast-line causes the rainfall to be exceptionally heavy, the Hymenophyllaceae attain a notable luxuriance, and abound

both in species and in individuals. In Westland they occur for the most part as epiphytes, clothing the trunks and overhanging boughs of the trees in sheets with their delicate drooping fronds, ranging from the forest-floor to the tops of the highest trees, and being distributed throughout the entire district from the coast-line to the subalpine zone. The suggestion to study the Hymenophyllaceae was made to me by Dr. L. Cockayne, F.R.S., some six or seven years ago, on my first going to live in Westland; and I have to thank him for many suggestions with regard to the scope of my work. Since then I have been able to examine thoroughly practically the whole of north Westland, as well as to see something of the forests farther south. My account of the Hymenophyllaceae as they here occur will be found, I think, to be fairly complete. I have also been able personally to study the family in the southern-beech and other forests of both Canterbury and Nelson at many selected places, and to trace its distribution in the Auckland District.

Map 1.—The New Zealand Biological Region.

Of the four species of the family which do not seem to occur in Westland, two—viz., *Trichomanes elongatum* and *T. humile*—I have been able to study in North Auckland, while fresh material of *Hymenophyllum atrovirens* was kindly sent to me, with field-notes concerning it, by Mr. W. J. Williams, of the City Engineer's Office, Dunedin. Mr. H. Carse, of Kaiaka, North Auckland, early in my work sent me ample material of *T. humile*. I am glad to take this opportunity of thanking both these gentlemen. The fourth species, *H. ciliatum*, has never been rediscovered in New Zealand since it was first reported from Nelson over fifty years ago, but through the kindness of Mr. Cheeseman I have been able to examine material collected in the West Indies. It will thus be seen that all of the New Zealand species have been available for the purposes of this study.

The original photographs were the work of Mr. C. Beken, of Christchurch, and were taken from specimens in my own collections. These illustrations may be regarded as typically showing the species as they occur in Westland, with the exception, of course, of those which I have not been able to find there. Mr. T. F. Cheeseman, F.L.S., has informed me that they well represent also the form shown by the species in the deep ravines of the wet districts of the North Island, adding that he sees no indication of distinct geographical races. I am greatly indebted to Mr. Cheeseman, who has on many occasions generously placed at my disposal his knowledge of the distribution of the Hymenophyllaceae in many parts of New Zealand. I have to thank also the Director of the Government Meteorological Department for kindly supplying me with the rainfall and other meteorological data included in this paper. Finally, it gives me much pleasure to acknowledge the kind invitation extended to me by the Director and the Chief of the Biological Department of the Cawthron Institute at Nelson to carry on my work at the Institute during the six months that I was in that district, an invitation of which I fully availed myself.



MAP 2.—North Westland, N.Z.

I. LIST OF THE SPECIES.

The following is the complete list of twenty-seven species which occur in the New Zealand Biological Region (see map 1), all of which, it may be added, are present on the main islands of New Zealand. The ten which, so far as is known, are endemic are indicated in the list by asterisks. For this information I am indebted to Mr. Cheeseman. For the full systematic description of the species reference must be made to the *Manual of the New Zealand Flora* (6). With the exception of *H. ciliatum*, whose existence in New Zealand is doubtful, all are illustrated in the present paper from photographs, the numbers in square brackets in the list corresponding to the number of the plates on which each species will be found. In accordance with the rules of priority in nomenclature the specific names of four of the species will be found to differ from those given in the *Manual*. Other plants

mentioned in this paper are also referred to under their corrected nomenclature :—

Hymenophyllum rarum R. Br. [56]
H. sanguinolentum Hook. f. (= *H. polyanthos* var. *sanguinolentum* Hook.) [57]
**H. villosum* Col. [58, 59]
H. australe Willd. [60]
**H. atrovirens* Col. [60]
**H. pulcherrimum* Col. [61]
H. dilatatum Swartz [62]
H. demissum Swartz [63]
**H. scabrum* A. Rich. [64, 59]
H. flabellatum Lab. [65]
**H. rufescens* T. Kirk [65, 76]
H. ciliatum Swartz
H. ferrugineum Colla (= *H. subtillissimum* Kunze) [66, 76]
H. Malingii Metten [66, 76]
**H. Armstrongii* Bak. (= *H. Cheesemanii* Bak. and *Trichomanes Armstrongii* Bak.) [67]
H. minimum A. Rich. [67]
H. Tunbridgense Smith [68]
H. peltatum Bearne (= *H. unilaterale* Willd.) [68]
H. multifidum Swartz [69]
H. bivalve Swartz [70]
**Trichomanes reniforme* Forst. [71]
**T. Lyallii* Hook. & Bak. [72, 76]
T. humile Forst. [73]
T. venosum R. Br. [72]
**T. Colensoi* Hook. f. [73]
**T. strictum* Menz. [74]
T. elongatum A. Cunn. [75]

Illustrations of all of these species, with the exception of *H. ciliatum*, are given in Field's *Ferns of New Zealand* (11). I must, however, point out that *H. minimum* and *H. Armstrongii* are there incorrectly figured. Four species—namely, *H. atrovirens*, *H. Malingii*, *T. Lyallii*, and *T. Colensoi*—are figured in Cheeseman's *Illustrations of the New Zealand Flora*, vol. 2 (7), and *H. Malingii* also in a paper by L. Cockayne, published in *The Plant World*, entitled "Some Noteworthy New Zealand Ferns" (9). Three species are figured in the *Transactions of the New Zealand Institute*—viz., *H. rufescens* (vol. 11, p. 457), *H. Armstrongii*, and *H. atrovirens* (vol. 10, p. 394). *H. pulcherrimum* is illustrated in J. D. Hooker's *Flora Novae Zelandiae*, vol. 2 (15).

The following seven New Zealand species are found also in Tasmania (25): *H. rarum*, *H. australe*, *H. flabellatum*, *H. Malingii*, *H. Tunbridgense*, *H. peltatum*, and *T. venosum*. Several of these, as well as *H. bivalve* and *T. humile*, occur also in New South Wales (20, 21). In his *Handbook* Rodway notes that *H. rarum*, *H. flabellatum*, and *T. venosum* occur commonly in Tasmania on the stems of tree-ferns, *H. australe* and *H. Tunbridgense* on mossy rocks, and *H. Malingii* on the bark of *Athrotaxis*† *selaginoides*, habitats which are closely similar to those adopted by these species in the less wet parts of New Zealand. Two additional species—viz., *H. multifidum* and *H. minimum*—are found on Lord Howe Island (23), whose flora gives evidence of both New Zealand and Australian affinities. Eight species are said by Cheesemen (6) to occur in Polynesia or Malaya—viz., *H. rarum*, *H. australe*, *H. flabellatum*, *H. dilatatum*, *H. demissum*, *H. multifidum*, *T. humile*, and *T. elongatum*. Two species—viz., *H. rarum* and *H. ferrugineum*—are found in South America, while *H. ciliatum* is well known from tropical America and tropical Africa. Two only, *H. Tunbridgense* and *H. peltatum*, are more or less cosmopolitan, although *H. rarum* is widely distributed throughout the Southern Hemisphere.

The New Zealand Biological Region includes, in addition to the three main islands of New Zealand, several outlying groups—viz., the Kermadec Islands to the north-east, the Chatham Islands to the east, and the Subantarctic Islands to the south. None of these outlying groups possesses species of Hymenophyllaceae which are absent from New Zealand itself. As is well known, the New Zealand flora as a whole is composed of several distinct elements additional to that peculiar to the country itself—namely,

† A common spelling of this genus is *Arthrotaxis*, but is is pointed out by Baker and Smith in their work entitled *A Research on the Pines of Australia* (Sydney, 1910) that the original spelling of Don, who established the genus, is *Athrotaxis*, and that this is in accordance with the derivation of the name.

H. rarum R. Br. Mesophytic and stunted forms. Nat. size.

Face p. 580.]

the Malayan, the Australian, the Fuegian, and the Cosmopolitan elements. It will be seen that these elements are represented in the New Zealand Hymenophyllaceae.

II. THE CLIMATE AND FOREST-COVERING OF WESTLAND.

As this paper deals particularly with the distribution of the Hymenophyllaceae in Westland, certain details concerning the climate and forest-covering of this part of New Zealand must be given. The dominant feature in the topography of the South Island is the snow-clad ranges of the Southern Alps, which extend throughout almost the entire length of the Island in more or less close proximity to the western coast, forming a natural high barrier in the path of the prevailing westerly moisture-laden winds. On account of this the western districts receive by far the greater part of the rains, and carry from the coast-line back on to the ranges a continuous heavy mixed forest. The chief topographical features in Westland to be taken into consideration are the very narrow coastal flats, the river-plains, river-terraces, and morainic hills, the isolated outlying ridges and mountains, the flanks of the main ranges, and the gorges through which the rivers emerge on to the lowlands, practically the whole area being heavily forested. These features are indicated in map 2, on page 579. The lowlands are, in north Westland, not more than twenty miles in width, becoming narrower still farther south on account of the coastwards trend of the ranges.

The climate is characterized by a heavy rainfall, an infrequency of high and especially of drying winds, and an absence of extremes of heat and cold. In the latitudes in which New Zealand lies the prevailing winds are from the north-west and the south-west, and are heavily moisture-laden. An east wind is very occasionally experienced in the lowlands of Westland—more frequently, however, on the flanks of the ranges—and this is cold and more or less dry: it is the only wind which is able to wither the fern vegetation in exposed localities. The precipitation takes place mainly on the western side of the Island, and especially upon the ranges themselves. The eastern side of the Island, on the other hand, experiences a dry climate, the north-west wind arriving over the mountains for the most part bereft of all its moisture. These heavy dry winds undoubtedly here play a chief part in determining the nature of the plant-covering. The greater part of this eastern area is covered by tussock-grass, but the eastern flanks of the main ranges and also of the outlying mountains of Canterbury carry a more or less continuous covering of the southern-beech forest, whilst the latter mountains in South Canterbury show in places, on account of the added southerly precipitation, a true rain forest. In my next paper I hope to give a detailed account of the distribution of the Hymenophyllaceae throughout this Eastern Botanical District, comparing it with their occurrence in Westland under the different conditions of altitude and forest-covering, and of rainfall and wind. Carefully collected facts with regard to the relative abundance of the species, the presence or absence of individual species, and the particular station in the forest adopted by them, and as well the growth-form exhibited by the more plastic members of the family, undoubtedly may be regarded as reliable indications of the climate prevailing in the interior of a forest, and should prove of use in general forestry work.

The subjoined meterological data (Table A) are given with the object of showing, by means of a contrast drawn between the climates experienced at the west coast (Hokitika) and east coast (Lincoln) respectively of the South Island, the very favourable conditions prevailing in the forests of Westland for the Hymenophyllaceae. All the data given in this table were taken in

TABLE A.

Meteorological Data for Hokitika and Lincoln, situated on the West and East Coasts respectively of the South Island, New Zealand, giving the Means for the Period 1911–20 inclusive.

—	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Year.
Rainfall, in inches—													
Hokitika	10·44	6·60	8·22	10·61	8·09	8·29	8·90	9·05	11·07	12·04	17·76	8·79	114·86
Lincoln	2·58	2·14	1·32	2·04	2·43	2·35	2·95	1·47	2·07	1·61	1·93	2·30	25·19
Rainy days—													
Hokitika	16·7	11·2	14·1	17·7	14·7	17·0	16·4	15·7	19·8	19·7	21·6	15·3	199·9
Lincoln	9·6	8·2	8·3	9·6	11·3	12·1	12·3	10·6	10·0	9·8	12·5	10·1	124·4
Mean humidity—													
Hokitika	77·0	77·6	76·5	76·3	73·2	75·9	73·1	72·9	75·5	77·7	79·6	79·5	76·3
Lincoln	68·2	70·8	69·3	71·9	74·5	76·5	76·7	74·9	71·6	69·6	69·5	68·2	71·7
Average daily velocity of wind, in miles—													
Hokitika (1911–19) ..	139·8	115·7	103·0	103·8	87·3	87·2	87·2	97·7	147·8	168·3	175·7	159·2	122·7
Lincoln	148·1	125·5	120·0	100·0	89·2	84·9	84·1	96·6	116·0	135·6	138·3	141·8	114·4
Sunshine, in hours and minutes—													
Hokitika (1913–20) ..	192 24	177 26	177 27	130 37	141 55	101 44	109 20	153 32	135 26	162 6	171 36	217 41	1871 14
Lincoln	217 85	188 12	197 5	152 45	137 55	113 40	124 73	153 50	176 5	218 5	208 32	213 65	2103 52
Shade temperature—													
Hokitika—													
Mean maximum ..	65·5	66·9	65·9	61·5	56·4	52·7	53·3	54·4	56·8	58·8	59·9	62·9	59·6
Mean minimum ..	51·5	52·6	51·1	47·5	40·3	38·2	37·6	37·9	42·6	45·4	47·0	49·1	45·0
Lincoln—													
Mean maximum ..	72·5	71·1	69·4	64·7	65·8	53·0	52·0	54·0	59·3	64·5	66·6	69·5	63·5
Mean minimum ..	50·6	54·4	49·3	44·7	39·3	36·2	36·0	36·6	40·5	43·8	45·7	47·5	43·7

the open, and do not, of course, refer to actual forest conditions. Moreover, the two stations mentioned are situated at sea-level, where the climate experienced will differ from that on the sides of the ranges. However, the general contrast will serve a useful purpose. The lack of drying winds in Westland—one of the most important facts for the present purpose, but one which cannot adequately be shown in a table—the low summer temperature and also daily range, the heavy rainfall and large number of rainy days evenly distributed over the whole year, all point to the fact that in its forests the humidity will be more or less consistently high, and that transpiration from frond and leaf surface will probably never be excessive. The fact that Hokitika lies in the path of the prevailing westerly moisture-laden winds is accountable for the greater average daily wind-velocity recorded there than at Lincoln, at which latter station the strong and exceedingly dry north-west winds are at certain times of the year frequently experienced.

The meteorological figures for Hokitika may be considered to represent fairly accurately the climate experienced throughout north Westland at the coast-line. Table B shows the amount of rainfall in inches and the number of rainy days at Hokitika for each month during the period 1911–20, from which it will be evident that Westland experiences neither seasonal dry periods nor even occasional periods of drought. This is, of course, an important fact to be noticed in connection with the distribution of the Hymenophyllaceae, since this family demands a constantly high atmospheric humidity which quite conceivably could be lacking notwithstanding a high annual rainfall.

TABLE B.

Detailed Meteorological Data for Hokitika, Westland, N.Z., showing Monthly Rainfall and Rainy Days for the Period 1911–20 inclusive.

—	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
1911.													
Rainfall ..	14·08	1·03	8·33	7·94	6·94	6·29	2·42	5·66	10·00	14·10	14·84	13·26	104·89
Rainy days..	7	5	12	15	8	13	6	12	17	17	24	20	156
1912.													
Rainfall ..	10·86	8·24	7·98	11·87	6·48	14·38	4·44	9·14	18·66	11·12	9·50	2·94	115·61
Rainy days..	12	9	13	19	12	20	9	14	25	16	17	11	177
1913.													
Rainfall ..	8·85	4·74	10·68	4·29	7·64	9·13	12·73	7·49	11·49	9·62	10·04	4·27	100·97
Rainy days..	22	17	25	15	17	17	26	15	28	19	21	17	239
1914.													
Rainfall ..	13·74	5·97	3·30	11·65	9·81	5·75	7·98	6·00	7·64	6·59	19·16	14·73	112·32
Rainy days..	23	9	10	23	13	18	21	16	15	21	24	21	214
1915.													
Rainfall ..	13·93	15·61	6·65	6·29	9·93	7·50	14·11	7·78	12·66	11·93	15·21	12·72	134·32
Rainy days..	24	20	14	18	16	15	16	13	22	27	24	18	227
1916.													
Rainfall ..	7·81	6·29	10·96	13·52	9·01	6·00	10·02	11·27	7·20	10·34	13·11	2·04	107·57
Rainy days..	12	13	16	13	17	15	13	22	16	16	21	4	178
1917.													
Rainfall ..	2·22	9·42	12·54	11·11	10·24	8·49	9·06	7·64	17·98	18·52	1·40	10·54	119·16
Rainy days..	11	12	14	19	21	17	25	15	20	22	13	17	206
1918.													
Rainfall ..	9·37	6·95	8·86	10·26	9·69	7·74	7·99	13·52	10·33	15·51	14·00	10·28	124·50
Rainy days..	13	15	9	21	18	18	18	16	20	21	24	16	209
1919.													
Rainfall ..	14·26	2·64	5·24	7·89	2·59	12·09	9·85	8·65	7·72	9·15	13·18	6·27	99·53
Rainy days..	27	10	14	17	7	19	16	21	17	18	23	16	205
1920.													
Rainfall ..	9·26	5·15	7·67	21·32	8·62	5·53	10·42	13·39	6·98	13·59	17·17	10·86	129·96
Rainy days..	16	12	14	17	18	18	14	13	18	20	25	13	198

The total annual rainfall at the western coast-line of the South Island increases from north to south on account of the coastwards trend of the ranges in that direction. This is indicated in the following summarized figures for four coastal stations, from Westport in the north to Okuru in the south, which have been copied from the *New Zealand Geological Survey Bulletin No. 18*, 1917: Westport, 78·36 in. over a period of twenty-three years; Greymouth, 100·90 in. over twenty-five years; Hokitika, 116·23 in. over thirty-four years; Okuru, 148·16 in. over ten years.

The heaviest rainfall in Westland is experienced on the western flanks of the ranges, and especially in the river-gorges. For example, the average annual rainfall at Otira (see map 2, on page 579) for the period 1911–20 was 195·55 in., and the number of rainy days 176·5. This station lies at the western end of Arthur's Pass, at an altitude of 1,255 ft., and its rainfall and other meteorological features are probably fairly typical of those of similar localities along the west side of the dividing range. From the point of view of the fern flora it is important to note that both westerly and easterly winds at Otira are far heavier, and the latter wind more drying, than in the lowlands of Westland.

Although the timber-milling industry has been well established in Westland for some considerable time, the area still wholly untouched is comparatively large, while in south Westland the forest is practically altogether virgin. This is in striking contrast to the condition of the various isolated forests in eastern Canterbury, where the pines have largely been cut out, and where the only primitive forest is that contained in scenic or water-supply reserve blocks.

The extreme type of New Zealand rain forest is found most characteristically in Westland. Here the southern beech, which farther north is present along with the taxads, is absent except in the extreme south. The two species *Nothofagus fusca* and *N. Menziesii* extend down from the north as far as the Taramakau Valley, but do not cross it, except to a negligible extent in the upper portion of that valley. The mountain species *N. Cliffortioides* occurs as a continuous forest along the eastern flanks of the dividing range, but outside the Westland boundary. The principal tree members of the Westland mixed heavy forest are *Metrosideros lucida* (the southern rata), *Weinmannia racemosa* (kamahi), *Elaeocarpus Hookerianus*, and the taxads *Dacrydium cupressinum* (rimu, or red-pine), *Podocarpus kahikatea* (kahikatea, or white-pine), *P. spicatus* (matai, or black-pine) and *P. ferrugineus* (miro). Of the smaller trees, whose tops constitute the forest story beneath the canopy, those usually present along with small trees of the above-mentioned species are *Quintinia acutifolia* (locally misnamed "white-birch"), *Carpodetus serratus*, *Ascarina lucida*, *Griselinia lucida*, *Schefflera digitata*, and various species of *Nothopanax*. The tree-fern *Dicksonia squarrosa* is everywhere most abundant, and also, although to a less extent, *Cyathea Cunninghamii*. This may be described as the prevailing association or heavy mixed taxad forest. It covers the coastal flats, the lowland river-terraces and morainic hills, and the lower slopes of the mountains. Other particular associations are those of the river-flats and of the higher mountain-slopes. In the former of these the white and black pines are practically the only trees present, and the undergrowth is composed largely of such small-leaved shrubs as the various species of *Coprosma*. Another association prevails at altitudes of from 1,500 ft. to 3,000 ft., and consists of the southern rata, the mountain-totara (*Podocarpus Hallii*), and the kawhaka (*Libocedrus Bidwillii*), the other above-mentioned

taxads being absent. The kawhaka descends also in some localities into the lowlands, where it forms a very characteristic feature. The last association to be noted is that in which the small-growing *Dacrydium Colensoi* (the silver or Westland pine), and to a less extent *D. intermedium* (the yellow-pine) are present. These are found chiefly in swampy terrace-land, and in the sapling stage, along with *Phyllocladus alpinus* and various young taxads, are abundant on the "pakihis" or sphagnum bogs where older trees have been cut out. They also occur in open places at higher altitudes.

Throughout the heavy mixed forest where the canopy is more or less closed the Hymenophyllaceae are very abundant both in species and in individuals. Where the larger trees are more scattered, or where they have been partly cut out, the slender sapling-like *Quintinia*, with its erect stems, is the dominant tree of medium size, tree-ferns are largely absent, and the Hymenophyllaceae, along with other epiphytes, are more scantily represented. Generally speaking, however, the tree-ferns are a characteristic feature of the heavy mixed forest throughout the lowlands, and their fronds constitute a close story next above the floor, sheltering a luxuriant growth of filmy and other ferns, mosses, and liverworts on their stems and on the floor and fallen logs. The story next below the canopy is composed of the tops of the mixed assemblage of shrubby trees, several of which have comparatively large leaves, whose horizontally-spreading branches are thickly covered with epiphytic ferns, while some of the latter, including several species of *Hymenophyllum*, along with epiphytic orchids and species of *Astelia*, spread up the trunks of the tallest trees, and flourish even in the canopy. In short, on account of the uniformly high atmospheric humidity prevailing throughout Westland, there is a very general and abundant distribution of the Hymenophyllaceae, the main differentiating factor in their regional distribution being that of altitude, another operating more locally being that of the particular forest subassociation present.

III. THE DISTRIBUTION OF THE SPECIES IN WESTLAND.

It is, of course, apparent that the study of the forest flora of any particular district involves the close comparison of gullies with hillsides and ridges, and also the detailed observation of the epiphytic flora from the tree-bases to the canopy, as well as the more general comparison of the lowland with the upland and subalpine floras. In studying the high epiphytes in Westland I have been greatly assisted by the sawmilling which is at work in many different localities, being thereby able to examine thoroughly the tops of large numbers of newly felled trees throughout the district. Wind-felled trees also were examined at every opportunity. With respect to the Hymenophyllaceae in the forests of Jamaica, Forrest Shreve (26) has drawn attention to the facts regarding the relative occurrence of the species on the mountain-slopes and ridges and in the ravines. He there found (*ibid.*, bottom of p. 189), with regard to both the Hymenophyllaceae and the epiphytes generally, that "the trees of the upper slopes have the same epiphytic flora that would be found in the upper two-thirds of the [height of the] trees of the ravines, while the trees of ridges and peaks have only those that are characteristic of the uppermost third, and the mid-height species are restricted in these habitats to the sides of prostrate trunks or fallen logs." I may state briefly that the present study bears out this statement in a general way with regard to the more widely ranging members of the New Zealand Hymenophyllaceae, but that since certain species are confined altogether to lower altitudes and others to higher,

and some again are altogether terrestrial or low epiphytic plants, a really satisfactory description of the distribution can only be gained by going into the question in much greater detail.

The only published information dealing with the occurrence of the Hymenophyllaceae in Westland is contained in a list of plants collected by A. Hamilton in the district of Okarito, south Westland. He there records (13) the presence of twenty species, omitting the four which I also have been unable to find, and also *H. australe*, *H. Malingii*, and *H. bivalve*. Hamilton was not able to explore the flanks of the ranges. In the same volume T. Kirk published some brief notes on a few of the species collected by Hamilton.

I have found that in Westland the species occur to a great extent in groups according to their habits. It will be convenient to refer to them as far as possible in these groups.

A. *The Groups of Species and their Occurrence.*

(a.) *H. dilatatum*, *H. scabrum*, *T. reniforme*. (Plates 62, 64, 59, 71.)

Beginning with those species which are more or less confined to the lowlands, there is first the group *H. dilatatum*, *H. scabrum*, and *T. reniforme*. Throughout the lowlands of Westland these three species are found in abundance, and almost invariably in close association. Up to an altitude of 1,200 ft. they occur as low and middle epiphytes, and at somewhat higher altitudes on mossy boulders and in a low epiphytic station, in gorgy streams on the mountains. In these last-named localities the prothalli and young sporeling plants of all three species can usually be found in abundance both on tree-trunks and on boulders, this showing that the humidity conditions are here especially favourable. All three species, however, are absent from the forests on the flanks of the ranges. *T. reniforme*, with its erect fronds, prefers large surfaces on which to grow, such as are afforded by the trunks of trees, but the two others keep to horizontally-growing boughs, from which they are pendulous. In various places in the lowlands where the larger trees have been cut out I have noticed these three species growing, though somewhat scantily, upon the floor, but in the heavier forest they are not to be found in this station. Their fronds show a comparatively very large extent of lamina. *T. reniforme* possesses a peculiar unsegmented form of frond, and the margin of the lamina is strongly thickened. The lamina of the frond-segments of *H. dilatatum* is very broad, and the segments tend to be confluent; the rhachis is also broadly winged. The fronds of this latter species and of *H. scabrum*, when pendulous, are as much as 2 ft. or more in length. A characteristic feature of *H. scabrum* is the clothing of reddish jointed hairs on the stipe (see Plate 59).

Apart from the fact that the fronds of *H. dilatatum* and *H. scabrum* assume a shorter and more deltoid form when growing erect on rocks, the species of this group are unable to modify the frond-form by stunting and imbrication after the manner of certain other mid-epiphytic species of the family. The fronds of *T. reniforme*, however, inroll closely under dry atmospheric conditions, and it is no doubt the possession of this character, combined with its short stiff frond-form, that enables this species to climb higher than the two others, and to endure a mid-epiphytic station in localities too exposed for the latter.

It is well known that these three species, contrary to what is the case in the family as a whole, possess in the adult frond a lamina which is several cells in thickness, and with respect to this character they have

been looked upon as the least-specialized members of the family. I may state briefly that from an examination of the sporeling plants of all three species I have found that the multi-layered condition is developed secondarily in the ontogeny and from the vein outwards towards the margins. The first-formed frond in all three species is of a simple linear form with an unbranched vein. The lamina is one cell in thickness, except immediately adjoining the vein, where it is three-layered, the outer dorsal and ventral cell-layers extending over the vein. Sections of succeeding fronds of young sporelings show that the next stage toward the multi-layered condition is attained by the development of a second and inner layer of small cells overlying the vein both dorsally and ventrally, at the same time the two or three interior cells of the lamina laterally adjoining the vein increasing in number by subdivision, and also in size, so that this multi-layered zone begins to extend outwards into the lamina proper. The further development of this zone results from indiscriminate periclinal and anticlinal divisions of the cells of both the outer and the inner layers of the lamina, so that in progressively older fronds both its gradual outward extension towards the margin and also the further increase in width of the inner layer of the lamina in the same direction can clearly be traced. In these young sporeling plants, and even to a much later stage in their development, there is a broad zone of lamina extending inwards from the margin which remains in the original one-layered condition, and the irregular edge of the multi-layered portion of the lamina where it adjoins the outer one-layered portion can easily be seen by the naked eye. In all three species the cells of the inner layer of the lamina are comparatively large, and probably function as a water-reservoir. In young sporelings of *T. reniforme* progressively older fronds show a repeated forking of the vein and of the lamina, so that the young frond becomes somewhat digitate in form. The lamina soon extends and webs the segments together, although the margin of still older fronds remains more or less crenate. The lamina of the adult composite frond of this species is multi-layered to the margin, but whereas it is five cells thick in the oldest basal parts of the frond, it becomes four and finally only three cells thick towards the margin. It must be added that in well-grown plants all new fronds are reniform from the first.

In the case of *H. scabrum* the multi-layered condition is attained much later than in the two other species, appearing first in the oldest parts of the developing frond. In this species the segments of the mature fronds and the wings of the rhachis permanently remain one cell in thickness for some distance in from the margins.

It is to be noted in this connection that in the case of *T. elongatum*, in which species also the frond-lamina is particularly extensive, the lamina is two or three cells in thickness in those parts of the pinnae where the larger veins converge, but only in the immediate vicinity of the veins—*i.e.*, the multi-layered condition does not extend outwards very far towards the margins. The pinnules of *H. demissum* show a circle of parenchyma one cell thick completely surrounding the veins, but in most of the New Zealand species even this is absent. Further details concerning the frond-anatomy of the New Zealand species cannot here be given, but the above facts have been mentioned to indicate that the multi-layered condition of the lamina in the three species of the group under consideration may, after all, be a specialized and not a primitive feature. This point will again be referred to.

No doubt the multi-layered condition of the lamina in these three species assists them, even in the absence of the ability to modify the frond-form, to endure the mid-epiphytic station, by ensuring a supply of water within the frond.

(b.) *H. ferrugineum* and *T. venosum*. (Plates 66, 76, 72.)

These two species form a very characteristic group, which also is confined to the lowlands. Along with *Tmesipteris* and *Lycopodium Billardieri* var. *gracile* they occur very commonly on the stems of tree-ferns, and more especially upon *Dicksonia squarrosa*. In the heavy forest of the lowlands these two species are rarely to be found on other than tree-fern stems, but at the foot of the ranges *T. venosum* occasionally occurs also on the bases of large forest-trees. In deep narrow ravines in the same localities *H. ferrugineum* not infrequently may be found on dripping mossy rock-walls, its fronds being here actually bathed in water to a far greater extent than most Hymenophyllaceae naturally seek. In such stations the fronds are apt to become very attenuated in form, some which were measured being 1½ ft. in length and only from ¼ in. to 1 in. in width. These two species are always low epiphytes, and are evidently strongly hygrophilous.

T. venosum is a small delicate species, and occurs in close mats, its fronds pendulous and overlapping. *H. ferrugineum* also occurs in more or less close overlapping colonies with pendulous fronds, but is less mat-like. The latter species is reddish-brown in colour, whence its name, being clothed on the surface and on the margins of the lamina with short stellate hairs (Plate 76). These two species have a range practically identical with that of the *Dicksonia*—*i.e.*, up to about 1,400 ft.—but this tree-fern in the Westland climate will flourish alongside forest-roads and in clearings where the humidity is not consistently high enough for the filmies. *H. ferrugineum* is rather more restricted in its regional distribution than *T. venosum*. In not a few localities on the lower slopes and at the base of the ranges where tree-ferns are abundant the latter filmy fern is present but not the former. The tree-fern fronds seem to give the close shelter needed, and the trunks afford a substratum more constantly damp than the bark of trees. The favourable nature of such a station for pteridophytic growth is attested by the fact that the prothalli and sporeling plants of both *Tmesipteris* and the *Lycopodium*, as also of various species of ferns, occur abundantly along with many small liverworts on the stems of *Dicksonia*. *T. venosum*, *H. rarum*, and *H. flabellatum* are said to occur commonly in Tasmania on tree-fern stems (25), and in rather drier parts of New Zealand, also, the two latter species frequently adopt this station along with the two which usually occur there. It will be noted that all these tree-fern-loving Hymenophyllaceae possess a filiform stipe.

T. venosum probably affords an example of reduction. The margins of the frond-segments are irregularly sinuate in outline, and the veins give rise to secondary and tertiary veinlets which end in spurious venules. Individuals can occasionally be found in which the pinnae are further divided, bearing from two to four sori.

(c.) *H. sanguinolentum*, *H. multifidum*, and *H. villosum*. (Plates 57, 69, 58, 59.)

Taken individually, these three species are the most abundant in the New Zealand family, not only in Westland but throughout the North and South Islands generally, although the last-named towards the north becomes more and more restricted to higher altitudes. In the middle lowlands of Westland they are to be found usually together, but whereas *H. multifidum* occurs from sea-level to the highest altitudes attained by the Hymenophyllaceae, and is an invariable member of this group, the two other species are more or less complementary in their distribution. *H. villosum* is absent from the coastal forest and is properly a mountain plant, while, on the other hand, *H. sanguinolentum* is abundant at sea-level but does not

H. sanguinolentum Hook. f. Mesophytic (upper half of frond) and stunted forms. Nat. size.

H. villosum Col. Mesophytic and stunted forms. Nat. size.

H. villosum Col. Young frond showing hairs. × 1½.
H. scabrum A. Rich. Stipe showing hairs. × 1½.

H. australe Willd. (centre). $\times \frac{7}{8}$.
H. atrovirens Col., showing two forms. $\times \frac{7}{8}$.

ascend much above 1,200 ft. As will be shown later, intermediate forms may sometimes be found at intermediate altitudes, which may equally well be referred to either of these species. Cheeseman notes (6, p. 932) that Hooker originally placed *H. villosum* as a variety of *H. sanguinolentum*, and remarks that the two are closely allied. The two species are very distinct, however, in the forms in which they usually occur, and in these forms, from the middle lowlands to the base of the ranges, occur commonly together, but the presence of intermediate forms undoubtedly gives added significance to the fact of their more or less complementary distribution. In the lowland forests *H. multifidum* and *H. sanguinolentum* are middle epiphytes, but they also occur here in the tops of the forest-trees in a stunted form along with several other species. In favourable places in the forest, where their fronds can hang from the undersides of horizontally growing boughs, they attain as middle epiphytes a most luxuriant growth. *H. villosum* descends as far as the middle lowlands, and it there occurs commonly with the two other members of this group in the tops of the rimu and other forest-trees, but not as a mid-epiphyte.

On the lower parts of the ranges *H. multifidum* and *H. villosum* occur commonly together both in the gullies as high epiphytes, and on the spurs and valley-sides on the lower branches of the trees, *H. sanguinolentum* being here absent. At still higher altitudes *H. multifidum* descends to the floor in moss, but *H. villosum* retains for the most part a low epiphytic station on the stunted trees. This difference in behaviour between the two species is found to hold also in other parts of New Zealand. When growing terrestrially *H. multifidum* adopts a very characteristic "mountain form" (Plate 69), in which the segments of the small strictly deltoid frond are more or less inrolled and overlap one another, and the frond as a whole is decurved and lies close to the moss in which the plants are growing. The short segments on which the sori are borne then bend sharply upward, so that the sori stand erect although the frond is practically horizontal. This mountain form is very distinct, and is found wherever the species occurs on the ground at altitudes above 1,500 ft. Occasionally fronds on terrestrially-growing individuals of the mountain plant may be found intermediate in form between the pendulous epiphytic and the deltoid terrestrial form, but this seems to be always when the fronds are able to hang freely. This species, along with *H. villosum*, is found also at altitudes above the subalpine forest, *H. multifidum* in sheets on moss or damp rock-faces and in other specially favourable places, and *H. villosum* in close mats on rocks and boulders and in other extremely xerophytic situations, as well as epiphytic on the shrubs. In sheltered gullies at lower altitudes the fronds of *H. villosum*, though generally deltoid in form and erect-growing, attain an extreme length of 6–9 in. and become pendulous, but in exposed situations at higher altitudes they are exceedingly stunted and imbricated. Moreover, in these latter situations the hairy clothing of the frond, from which this species derives its name, is well developed, not only the rhizome and young fronds but also the mature fronds, which in more mesophytic situations are bare of hairs, being strongly villous.

Along with the changes which take place in this association as we proceed from lower to higher altitudes it is found that even in the middle lowlands, in localities where for some particular reason the humidity is liable to unusual fluctuations, *H. villosum* is the member most consistently present and *H. sanguinolentum* the one most likely to be absent. For example, in the small-leaved totara-coprosma scrub which commonly occurs on the river-valley flats under the white and black pines, or still higher

up the flats where the latter are absent, the three species occur abundantly and together as low epiphytes wherever the thicket is tall and close. Even *T. reniforme*, and sometimes also *H. dilatatum* and *H. scabrum*, may occur here, though somewhat scantily, whenever a greater variety of shrubby trees is present. But where the thickets are more open *H. villosum* alone is present, though still as an abundant epiphyte. These river-flats are more open to the effects of the infrequent but drying east winds off the mountains than are the closer forests of the terraces and coastal flats, and the moss and epiphytes on the shrubs are at these times liable to be shrivelled for several days together. It is noticeable that *H. villosum* can recover from such shrivelling to a more marked degree than either *H. sanguinolentum* or the ordinary mesophytic form of *H. multifidum*.

(d.) *H. flabellatum*, *H. rarum*, *H. rufescens*, and *T. Lyallii*. (Plates 65, 56, 72, 76.)

The next group to be considered consists of four species whose characteristic habit is that of occurring in close colonies in large crevices and other overhung places on the bases of large trees, and also, in the case of the two first-named, on the underside of leaning tree-trunks and stout branches. *H. rufescens* does not descend into the lowlands, and *T. Lyallii* also prefers the mountain-flanks, although it descends occasionally to sea-level; but the other two species are more wide-ranging. They all agree in the slender capillary nature of the stem and rhizome. The two larger-growing species, *H. flabellatum* and *H. rarum*, are characteristically pendulous in habit.

H. flabellatum and *H. rarum* are abundant throughout the lowlands as middle epiphytes on large-stemmed trees, where they adopt the overhanging station. Here they frequently grow most luxuriantly, the fronds of both species attaining an extreme length of 9–12 in. It is noticeable how rapidly these two species respond to changes in the environment, on the same tree-trunk the growth-form being open with elongated fronds, or, again, mat-like with fronds stunted and pinnae closely imbricating, according to some change in the surroundings which cannot always be discerned. On account of the ease with which they can thus modify the growth-form, they are able to occupy in their stunted form comparatively xerophytic stations, being found commonly in the lowlands as high epiphytes in mats in the canopies of the forest-trees, although *H. flabellatum* to a less degree than the other. In the gullies on the ranges they ascend half-way up the largest trees, but it is to be observed that *H. villosum* and *H. multifidum* overtop them in such localities.

On the sides of the mountain-valleys, and on the ridges and flanks generally, all four species occur abundantly as low epiphytes on the large bases of the rata and mountain-totara. *H. rufescens* and *T. Lyallii* attain here their optimum development. The fronds of these two species are hairy (Plate 76), the hairs in the case of the latter being branched and confined to the margins of the lamina, and in the former being long and silky and of a simple form, thickly clothing the stipe and rhachis and the costae on both sides of the frond. These two small-fronded species are practically fixed with respect to the frond-form, and do not stunt or imbricate. They never vary from the low epiphytic station, and always preserve the mat growth-form with more or less overlapping fronds. In accordance with the fact that in the lowlands *H. rarum* is a somewhat more pronounced high epiphyte than *H. flabellatum*, it is found that on the mountain-sides the former invariably occupies a slightly higher position

on the tree-trunks than does the latter, these two species overtopping the other two smaller species. *H. rarum* is occasionally to be found also in close mats on the perpendicular damp rock-walls of open ravines from which *H. flabellatum* is absent.

I have rarely found the fronds of any of these four species wilted. In the gorges on the main ranges, after some unusual period of drying east winds, when practically all the epiphytic ferns and mosses show signs of drought, it is to be observed that even the large-sized fronds of *H. rarum* and *H. flabellatum* in a mid-epiphytic station are generally quite unaffected. It is to be noted that both these species are unusually coloured, *H. rarum* being a pale grey-green or even sometimes grey-blue colour, and *H. flabellatum* having a somewhat yellowish tinge. It may be that the colour acts as a protection, enabling the protoplasm in the frond-cells to withstand greater degrees of insolation and drying. The strap-shaped prothalli of *H. rarum*, and also the first-formed fronds in the sporeling plants, are of exactly the same colour as the adult fronds, and I have found the prothalli of this species, as well as both young and older plants, altogether unaffected by drought when the moss in which they were growing was dry and shrivelled. *H. rufescens* and *T. Lyallii* are clearly more hygrophilous than are the other two species, and in their sheltered station are less exposed to the danger of shrivelling.

Intermediate forms can sometimes be found at mountain altitudes which seem to link up *H. flabellatum* with *H. rufescens*, although these two species for the most part occur side by side in their usual distinctive forms. With regard to specimens of *H. flabellatum* collected on the subantarctic Auckland Island, Cheeseman says (22, p. 436) "they belong to a curious form intermediate between *H. flabellatum* and *H. rufescens* . . . which could almost be referred to either species." I may add that I have collected such intermediate forms also on Mount Hope, in the Nelson District. As Cheeseman indicates (*loc. cit.*), however, the stipe and rhachis of *H. flabellatum*, especially in its most stunted rufous form, never become quite so slender as are those of *H. rufescens*, and the frond of the latter always preserves the more delicate form characteristic of it.

(e.) *H. Tunbridgense, H. peltatum, H. Armstrongii, H. minimum.* (Plates 68, 67.)

These four species are among the smallest in the New Zealand family, showing typically the close mat growth-form, and may for this reason conveniently be grouped together. Of these the two latter are quite diminutive in size. *H. Armstrongii* is, in Westland, the most widely distributed of these species, occurring very commonly both as a low and as a high epiphyte, and ranging from the sea-coast to the upper limit of forest on the ranges. On account of its small size it is liable to be overlooked, especially as it usually grows in moss. In the lowlands it occurs quite commonly as a low epiphyte on the smooth sapling-like stems of *Quintinia* and young kamahi, on which a very thin, scanty moss covering, a most suitable substratum for such a small plant, is often present. In this station the individual plants are usually long-drawn-out and not aggregated into mats. It also occurs commonly in a more mat-like form in the tops of the tall taxads throughout the lowlands along with the other high epiphytic filmy ferns mentioned already. It is abundant on the mountain-flanks also up to an altitude of 3,000 ft., both on the stems of *Quintinia* and occasionally also in mats on mossy stones. I have also found this species in the neighbourhood of Otira growing in dense mats

on the wet rocky walls of open ravines, situations which lie outside the shelter of the forest altogether. In such exposed localities as that last named extreme and rapid fluctuations in the atmospheric humidity will undoubtedly be frequent, and it is to be noted that the only Hymenophyllaceae which can endure these conditions are those which can adopt most typically the mat growth-form—viz., *H. villosum*, *H. multifidum*, *H. rarum*, *H. Armstrongii*, and *H. minimum*.

The frond of *H. Armstrongii* sometimes possesses a strong, dark, thickened margin, and this character was at one time interpreted as an evidence of reduction. It was also supposed to constitute a distinct form, which was accordingly given specific rank under the original name *H. Armstrongii*, the name *H. Cheesemanii* being kept for the form which lacked the marginal thickening. It has long been recognized, however, that the marginal thickening is a very variable character, and for many years the name *H. Armstrongii* has not been used. The latter name has lately been applied again to this plant instead of the other, on the ground of priority. I have found fronds of this species showing every stage in the development of the marginal thickening. This begins at the tips of the strong marginal teeth, and shows itself clearly as a brown coloration extending to the base of a tooth, and being continued along the margin of the frond to the tooth next below. It would seem to be best interpreted —as has been done by Giesenhagen (12, p. 440)—as a means for keeping the little frond flat and rigid, and for preventing curling and tearing of the lamina.

Cheeseman notes (6, p. 939) that *H. minimum* "appears to be a littoral plant, never found far from the sea." I have found it in Westland in only three, yet widely separated, localities, in each case far from the sea-coast. These three localities are the scrub-covered terminal moraine of the Franz Josef Glacier, in south Westland; low shrubby trees on the Koiterangi Plain, in the Hokitika River valley; and damp rocky walls in the lower part of the Otira Gorge.* I may add that Mr. G. Anderson, of West Oxford, Canterbury, has recently forwarded me specimens of the same species collected by him from a rock-face in Gamman's Creek, near Mount Oxford, Canterbury. It is evident, therefore, that this species is by no means a littoral plant; but it certainly appears to have a somewhat discontinuous distribution. Owing to its diminutive size, however, it is, like the preceding species, liable to be overlooked. Judging from the few localities in which I observed it, *H. minimum* is a low epiphyte or rupestral plant, which, like *H. Armstrongii*, grows in mats in short moss, and in exposed situations at higher altitudes adopts a very close mat growth-form. The sori, which, relatively to the size of the plant, are large, are borne terminally, one on each frond. Occasionally instances may be found in which a frond bears two sori.

Judging from their occurrence in Westland, *H. Tunbridgense* and *H. peltatum* are complementary in their distribution, and a comparison with the distributional data from other parts of the South Island shows that this is undoubtedly the case. The former species is extremely abundant throughout the lowland forests of Westland as a low epiphyte, and

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* Since writing the above I have found *H. minimum* growing abundantly in thick mats, on boulders and on the ground in moss, in damp wooded situations, along a considerable length of the Taramakau River terrace, five miles below Otira, at an altitude of about 900 ft. From its notable abundance in this locality it seems probable that this species is by no means scanty in its distribution.

H. pulcherrimum Col. Upper third of frond, and also the complete stock and the stipe. × $\frac{2}{3}$.

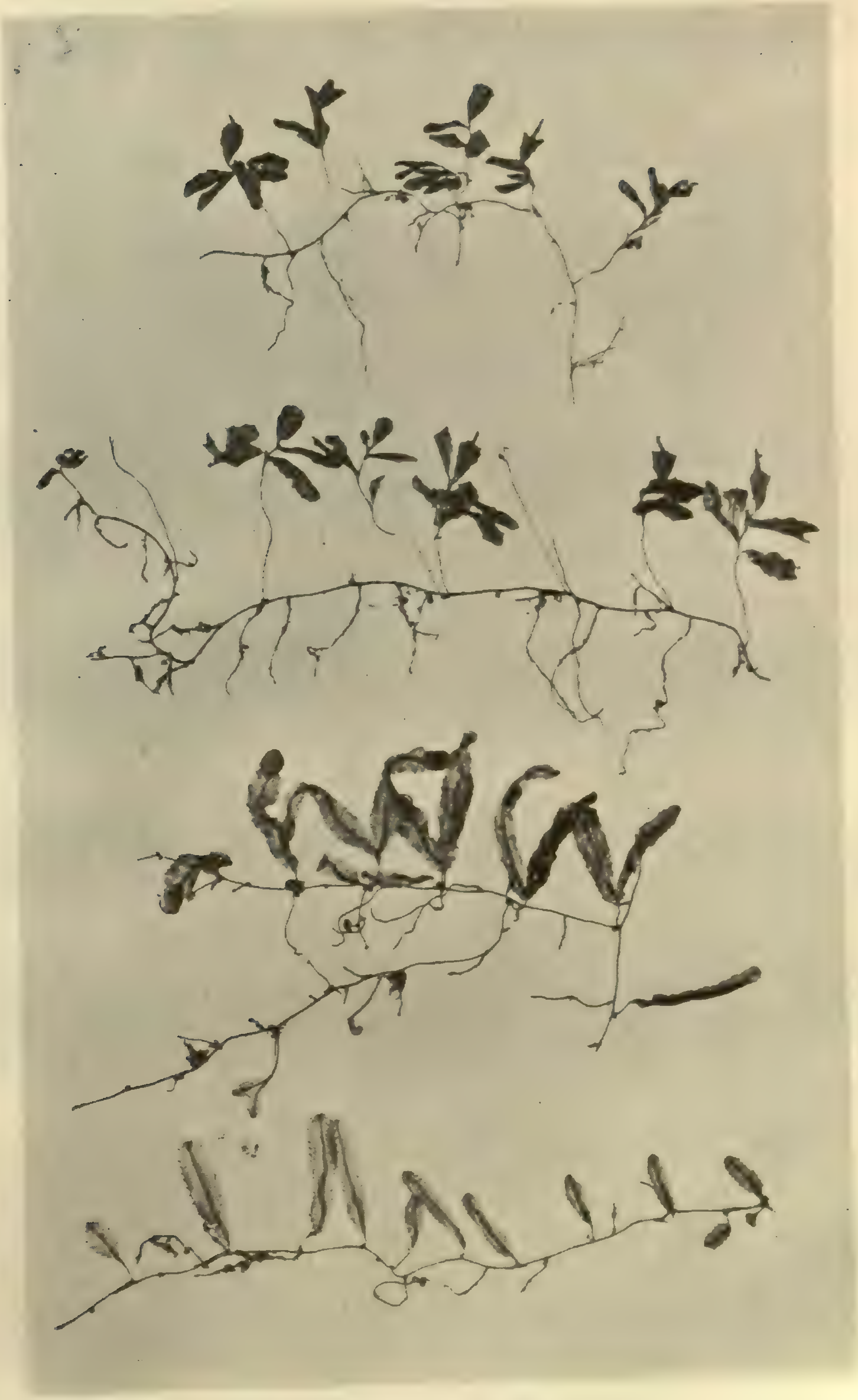
H. dilatatum Swartz. × $\frac{5}{8}$.

H. demissum Swartz. $\times \frac{7}{8}$.

H. scabrum A. Rich. × ⅔.

H. flabellatum Lab. Mesophytic and stunted forms. $\times \frac{7}{8}$.
H. rufescens T. Kirk (below). $\times \frac{7}{8}$.

H. Malingii Metten (left). Nat. size.
H. ferrugineum Colla (right). Nat. size.



H. minimum A. Rich. (above). × 2.
H. Armstrongii Bak. (below). × 2.

H. Tunbridgense Smith. Four varieties. Nat. size.
H. peltatum Bearne (below). Nat. size.

on fallen logs, mossy boulders, &c. It occurs also at the bases of the mountains, and more especially in the valleys and creek-beds up to an altitude of about 1,300–1,400 ft., although it is here more locally and scantily distributed. *H. peltatum*, which is also a rupestral and low epiphytic species, is confined in Westland to ravines and creek-beds in the mountain-forests at altitudes above those to which *H. Tunbridgense* ascends. It is less common in Westland than on the eastern side of the South Island. In the Eastern Botanical District *H. Tunbridgense* is the rarer species, being apparently absent from the southern-beech forest. I have never observed the two species overlapping in their distribution on the Westland mountains, although, naturally, in accordance with the difference in the climate between a ravine and the neighbouring mountain-flank, the altitude at which the one species gives place to the other varies slightly from place to place. I have found intermediate forms at intermediate altitudes, which will be referred to below.

H. Tunbridgense is extremely variable in its frond-form, but from the fact that the different forms are not found intermixed, and that they are characteristic of slightly different stations, it would seem that they are the expression of small differences in the environment. Four such forms commonly to be seen in Westland are represented on Plate 68. That marked D shows the species in its normal state. A is a much larger-fronded form, with large sori, occasionally to be met with on the under-side of fallen logs. B is an attenuated form which I have met with both on bare overhanging tree-trunks, where the fronds are freely pendulous, and also more especially in thick moss on the wet rocky walls of narrow ravines. In the latter station fronds were found up to 6 in. in length in which the lateral pinnae throughout the frond remained so completely undeveloped as practically to function only as short peduncles to the sori. It was shown above that *H. ferrugineum* also adopts the attenuated form when growing in moss on the dripping vertical rocky walls of narrow ravines. The smallest form, C, is that adopted by *H. Tunbridgense* very commonly when growing at a rather greater height above the ground than usual. It no doubt represents an adaptation to a more variable atmospheric humidity. At Waimate in Canterbury, and in several localities in the neighbourhood of Nelson, I have found that this species assumes a form in which the segments of the frond are broader, the primary pinnae more developed, and the frond as a whole much larger and heavier than in any of the Westland varieties noted above. The sorus is also here especially large. This variety is not illustrated at Plate 68. Of all these varieties the latter alone can possibly be taken as indicating that in this species there may be fixed geographical races, but the extraordinary variability of *H. Tunbridgense* suggests that it represents a stock from which other species have diverged.

H. peltatum occurs in two main forms according as the situation is secluded or exposed. In narrow forest-sheltered gullies among the mountains this species may be found in thick wet moss on the horizontal boughs of the *Fuchsia* and *Olearia* shrubs which so commonly occur in these water-courses. Here it grows most luxuriantly, the fronds commonly showing when pendulous two or even more fertile zones (see Plate 68). It also occurs at the same altitudes in larger open creek-beds in close mats on the boulders, the fronds here being stunted and curled with imbricating pinnae. This species is never found in Westland on the actual flanks of the mountains, but is restricted to the more humid and sheltered gullies.

The chief characters separating *H. Tunbridgense* from *H. peltatum* relate to the branching of the pinna, the disposition of the sori, and the nature

of the indusium. In the latter species the pinnae are pinnatifid on the upper side only, whence the name "*unilaterale*," by which formerly it was known. Closely related to this character is the disposition of the sori on the upper side of the pinna in a row of from two to four, whereas in *H. Tunbridgense* they normally occur singly at the base of the pinna. Perhaps the most important distinction between the two species lies in the fact that the margins of the valves of the indusium in *H. Tunbridgense* are spinulose-dentate, but in *H. peltatum* are quite entire. For the most part these distinguishing features are very constantly present, so that the two plants can readily be identified. Occasionally, however, with respect to each of the characters just noted, I have found intermediate forms, and these have always occurred at altitudes at which the one species gives place to the other. Undoubted plants of *H. Tunbridgense* have been found showing the pinnae divided unilaterally, and in one instance with the sori in rows. Again, the margin of the indusium in this species is sometimes only slightly crenulate. On the other hand, the indusial margin in *H. peltatum* is occasionally distinctly crenulate instead of being quite entire. Referring to *H. peltatum*, J. D. Hooker (15, p. 12) says, "This differs from *H. Tunbridgense β cupressiforme* only in the entire lips of the involucre, otherwise these plants appear identical. I find the amount of toothing in the valves of *H. Tunbridgense* to vary extremely, sometimes amounting to a mere erosion, and at others the lips being even laciniated and spinulose, so that I can hardly doubt these two proving eventually the same species."

In the same connection I may note that the specimens of *H. minimum* sent to me by Mr. G. Anderson from Oxford, referred to above, showed in most cases the presence, but in others the complete absence, of the most important and usually invariable character which separates this species from small forms of *H. Tunbridgense*—namely, the occurrence of spine-like teeth on the backs of the valves of the indusium as well as on their margins. As mentioned above, the sori in this tiny species are usually borne singly on each frond, terminating the main rhachis, but occasionally fronds bear two sori. The sorus as a whole is unusually large, and the receptacle somewhat exserted, approximating in form to that of *H. multifidum*, so that *H. minimum* might conceivably be a much-reduced form of this species. J. D. Hooker (14, p. 104) suggests that *H. minimum* is akin to *H. multifidum*, but adds that both the small size of the former and the spinulose valves of its involucre afford excellent specific characters. He proceeds: ". . . between this plant [*i.e.*, *H. minimum*] and *H. caespitosum* of the Falkland Islands and Cape Horn much analogy exists, especially in size, locality, and habit. In each the fronds are generally once divided . . . both have the indusia free or nearly so, spinulose at the back of the valves, and, though often lateral in the latter plant, the fructifications are, especially on small specimens, very generally terminal, and may prove to be truly lateral in *H. minimum* should that plant be found in a more luxuriant state."

(f.) *H. demissum* and *H. bivalve*. (Plates 63, 70.)

Of the New Zealand species of the genus *Hymenophyllum* these two are the most characteristically terrestrial species. *H. demissum* occurs throughout Westland from the sea-coast to the stunted upper forest on the ranges. *H. bivalve*, in the mixed southern-beech and taxad hilly forests of the Nelson Province, and, more especially in its drier and lighter pure southern-beech forests, is an exceedingly abundant terrestrial plant along with *H. demissum*.

In Westland, however, *H. bivalve* is much more restricted in its distribution. It is not uncommon on the flanks of the ranges in north Westland, and even descends to the lowland hills, but I have not found it at lower altitudes, nor south of the Hokitika River. Throughout New Zealand it keeps to hilly forests in preference to those of the lowlands, and is undoubtedly an upland plant. These two species are alike in possessing a strong creeping rhizome with erect or somewhat decurved rigid deltoid fronds. *H. demissum* in Westland prefers a sloping well-drained forest-floor, and for this reason probably is not so abundant on the flatter wet floor of the lowlands as on the lower slopes of the hills and ranges, in which latter localities it occurs abundantly in extensive open colonies. In places where the forest-covering is especially close *H. demissum* may ascend the trunks of large trees and tree-fern stems to a height of 6–8 ft., but in Westland this is an unusual habit with this species. *H. bivalve*, on the other hand, shows a more marked tendency to become a low epiphyte, and this habit it preserves in other parts of New Zealand.

The frond-form in these two species scarcely varies, and even when epiphytic they possess the erect habit and deltoid form of frond-growth.

(g.) *The Remaining Species.*

It will be convenient to refer to the remaining species individually.

H. australe (Plate 60) is not found in natural association with any other member of the family. It is fairly abundant in the heavy forest of the lowlands of Westland and up to an altitude of 500 ft. or 600 ft., but does not ascend much above 1,000 ft., and at the latter altitudes is only to be found in especially humid localities. It occasionally occurs on mossy rocks, but in Westland is typically a low epiphyte on the bases of large trees, up which, in very favourable localities, it may ascend to an extreme height of 10–12 ft. Like the last two species described, it has a strong creeping rhizome with an erect deltoid habit of frond, but it may occasionally be found growing most luxuriantly with pendulous fronds as much as 15 in. in length. Thus, judging from their habit of growth in Westland, the three species *H. demissum*, *H. bivalve*, and *H. australe*, taken in this order, present a gradual progression in the change from the terrestrial to the epiphytic station. A conspicuous character of the frond in *H. australe* is the very broad crisped wing, which extends almost to the base of the stipe. Altogether, in both its vertical and its regional distribution, this species must be considered more hygrophilous even than such large-fronded species as *H. dilatatum* and *H. scabrum*, which also possess an extended lamina. It is of interest to note that *H. sanguinolentum* may occasionally be found with the same crisped and broad wing-development as is so characteristic of *H. australe*, the two species being then somewhat similar in appearance.

As previously stated, I have not found *H. atrovirens* (Plate 60) in Westland, but since this species is evidently closely allied to *H. australe* a short comparison of the two may appropriately be made here. *H. atrovirens* has not been reported frequently in New Zealand, but it always appears to be a rupestral or low epiphytic plant, and occurs at rather higher altitudes than the other species, or "on stones in gorgy streams," as Mr. Cheeseman informs me. Thus the two species seem to be complementary in their distribution. As has already been shown, there are several such pairs of species in the New Zealand family. With regard to *H. australe*, there is no doubt that the frond becomes more luxuriant when pendulous than it is when erect-growing. I have received specimens of *H. atrovirens* collected from mossy gully-walls near Dunedin whose pendulous fronds were stated

by Mr. Cheeseman, to whom I submitted them, to be "a large slender state" of this species. Although for the most part each species has a very characteristic frond-form, yet it is evident that they are in a more plastic condition than such species as *H. demissum* or *H. bivalve*, and it seems likely that one species is a derived form of the other. Since *H. atrovirens* is endemic to New Zealand, it seems reasonable to regard it as the more specialized form of the two.

H. pulcherrimum (Plate 61) is the only New Zealand species of *Hymenophyllum* which is tufted in its growth-form. The rhizome is rarely more than 1 in. in length, generally less, being in some cases truly erect and in others inclined. In Westland it ranges from the middle lowlands to an altitude of 2,000 ft. It is most characteristic of the deep, closely sheltered creek-beds and ravines on the lower flanks of the mountain-ranges and outliers, where it is to be found as an abundant epiphyte in thick moss up to a height of 20 ft. above the ground. It does not seem to occur in the flat coastal forest, and hence may be regarded as an upland plant. The pendulous fronds of this species probably attain a larger size than do those of any other of the New Zealand family, in favourable localities frequently reaching a length of 2 ft. to 3 ft. It differs widely in form from any other New Zealand species.

H. Malingii (Plates 66, 76) is certainly the most peculiar species of the New Zealand family both in its frond-structure and in its distribution. The extremely xerophytic frond has been described and figured by Giesenhagen (12), and L. Cockayne (9) has drawn attention to the fact that this plant is practically restricted to the dead trunks of *Libocedrus Bidwillii* (kawhaka), and has given photographic illustrations both of the frond and of the colony.

In Westland, *Libocedrus* is a common member of the subalpine forest association, but it also descends in places into the lowlands. The restriction of *H. Malingii* to the trunks of this tree in Westland I have found to be practically invariable. The similarity in the outer surface of the trunks of the kawhaka, rata, and mountain-totara, which together make up the subalpine forest association, led me to give particular endeavour to discover whether or not *H. Malingii* occurs on either of the two latter as well as on the former, but out of some thousands of trees examined from time to time I must say that I only once found this species growing on an old rata-stump, and then but scantily. On the kawhaka, however, it grows most abundantly, and must be reckoned an abundant species throughout Westland. As has been indicated, it prefers the lower parts of dead standing trees and old stumps, and it may also be found on fallen moss-covered logs which have almost mouldered away through age. It forms fairly close colonies, with the fronds pendulous and overlapping, and it has a characteristic habit of running vertically up a standing trunk in a narrow streak to a height of 18–20 ft., following a crack or groove in the stem-surface. Its slender rhizomes ramify in the still-firm outer wood to a depth of 2–3 in. by means of the innumerable cracks and fissures. It may be that these cracks not only serve to give the *Hymenophyllum* a firm holding-place, but also act as reservoirs of water. However, I have never seen any other member of the family epiphytic on the dead kawhaka.

H. Malingii is found also in Tasmania, and Rodway (25, p. 290) states that it there occurs "on the bark of *Athrotaxis selaginoides* Don in damp shaded places." L. Cockayne (9, p. 55) notes that it has been reported in the Waimarino district, in the North Island of New Zealand, on *Dacrydium intermedium*. Field (11, p. 67) states, without mentioning the locality, that

it occurs at high levels on the decaying trunks of *Phyllocladus alpinus*. Potts (24, p. 359) records it as occurring on the hills of Banks Peninsula, Canterbury, on *Podocarpus totara* as well as on *Libocedrus Doniana*. Cheeseman (7, note to plate 235) remarks on its abundance on dead trunks of *Libocedrus Bidwillii* in the forests to the west of Mount Ruapehu, North Island, but states also that it has been found in the South Island on *Podocarpus Hallii*. Its partiality for the stems of conifers may be determined by some chemical property in their tissues. I have found it, however, growing terrestrially and most luxuriantly in thick moss in sheltered places between large granite boulders on Mount Hope, in the Nelson District, and also on the vertical faces of some of the smaller of these boulders, a station which in this particular locality was commonly adopted also by several other species of *Hymenophyllum*. Although the *Libocedrus* was not here in the immediate vicinity, it was abundant at somewhat lower altitudes. Mr. F. G. Gibbs, of Nelson, informs me that he has found it in a very similar station on rocks on the forest-covered summit of Mount Parapara (Nelson District), *Libocedrus* being present near by with *H. Malingii* upon it. The distribution of this species remains, therefore, rather a puzzle. In districts where *Libocedrus Bidwillii* is not abundant it may be found on certain other conifers, but when the *Libocedrus* is abundant, as in Westland, it is apparently confined to that tree, although the others are present alongside.

Other species of *Hymenophyllum* are higher epiphytes than *H. Malingii*, and occupy more exposed positions, but none of these, except possibly *H. dilatatum*, *H. scabrum*, and *T. reniforme*, shows any anatomical modification of the frond in accordance with its station. On the other hand, the frond of *H. Malingii* is modified to an extreme extent, so that in this respect it is probably the most remarkable member of the family. It will be sufficient to state briefly that the frond has no assimilating lamina comparable to that of other species. The vascular bundle in all parts of the frond is encircled by thick-walled tissue showing pores in the cell-walls, the outermost limiting layer being thin-walled and protruding as long cylindrical papillae. These latter contain chlorophyll, and function as the assimilatory tissue. The papillae are separated from one another by narrow air-spaces, into which water can be drawn in times of rainfall and held during periods of drought. As a protection against transpiration and evaporation of this water-film, the entire outer surface is covered by closely interlocking stellate hairs whose bases extend down between the papillae, the stellate portions resting closely against their tips. So entirely is the surface of the cylindrical segments of the frond covered by these hairs that the latter impart to it a characteristic grey or rusty-brown colour, and it is only when the frond is completely sodden with water, so that even the cavities of the hairs are filled—a phenomenon but rarely to be observed—that the underlying green colour of the chlorophyll tissue can be seen.

Trichomanes strictum (Plate 74) is one of the two tufted New Zealand species of *Trichomanes*, the other being *T. elongatum* (Plate 75). The former is a fairly abundant plant throughout the forests of Westland, ranging from sea-level to an altitude of at least 1,500 ft. The latter is apparently absent from Westland, but it has been reported by Townson (27) from the Westport district. It is abundant in the northern part of the North Island, but is distributed more rarely and locally southwards. Both species are terrestrial in habit, and seek out the most shaded and secluded places in the forest. *T. elongatum* prefers the actual banks of small watercourses, although not confined to them. Other writers have drawn attention to the shade-loving habit of this species. In this respect,

and in the dark and at times almost black colour of its fronds, it may be compared with such other extreme shade- and damp-loving ferns as *Blechnum nigrum* and *Leptopteris superba.* Its fronds are frequently covered with small epiphyllous mosses and hepatics. Although *T. strictum* is more wide-ranging than the other species, I have observed that in Westland it is for the most part confined to the interior of the hollow fern-covered stumps of large decayed trees or to tree-base crevices or the under-side of overhanging banks. In such situations it has to be searched for before it can be seen.

In their favourite localities these two species occur mostly in colonies, and prothalli and young sporelings can commonly be found in abundance. Whether it is that in these sheltered places these species are avoiding the light, or seeking extremely humid conditions, or rather that they here find a more suitable substratum for a nursery-bed than on the leaf-covered, more open forest-floor, is not altogether clear. Being tufted in their growth-form, they are altogether dependent upon spore-germination for their continuance and spread. Probably the last-mentioned of these governing influences may be the most important, and in this connection H. Carse's observation (5, p. 76) is significant—namely, that at Kaitaia, in North Auckland, *T. strictum* occurs on the open moorlands on the margins of the man-made kauri-gum potholes — localities which I have myself found to shelter frequently young sporeling plants of *Lycopodium laterale.*

These two species are considered to be allied to the more widely spread *T. rigidum* Swartz, but they are quite distinct from one another as regards both the form of the frond and also the cellular structure of the lamina, although alike in general habit. Moreover, in *T. strictum* the pinnules are deeply dissected into long narrow segments, but in *T. elongatum* there is a much more continuous expanse of lamina, and the pinnules are rather toothed than segmented. This distinction between the two species is further emphasized by the fact that whereas the adult prothallus of *T. strictum* takes the form of a tuft of filaments, as in so many species of this genus, that of *T. elongatum* has but a brief initial filamentous stage, and develops into a large strap-shaped tissue-body whose meristem is situated at the base of a sinus at its forward end, the archegonia being borne on a series of cushion-like thickenings behind the meristem.

Trichomanes Colensoi (Plate 73) is a small mat-forming species which is abundant on the lower flanks of the ranges throughout Westland. It grows on the under-side of damp boulders and rocks both in the mountain stream-beds and on the sides of the mountain-valleys. It apparently does not occur in the lowlands. I have never found it on other than boulders or rocks, the small fronds being always pendulous from their under-side, although rigid enough to stand erect. Cheeseman states (6) that it is also epiphytic on trees—presumably at their base. In very sheltered localities the fronds grow luxuriantly, the pinnae bearing three or four sori, instead of, as is usual, only one or two. With this species may be compared *T. humile* (Plate 73), another small and delicate creeper. This plant, like *T. elongatum*, does not seem to occur in Westland, but is more characteristic of the northern districts of the North Island. It also, however, has been reported by Townson (27) from the Westport district, and it is, of course, possible that both species may yet be found to occur, though scantily, in special localities in Westland. *T. humile* is generally a terrestrial plant, growing in mats, in much the same way as *T. Colensoi*, on overhanging banks of streams and damp rock-faces and boulders, from the under-side

of which it is pendulous. Less frequently it may be found pendulous from the under-side of leaning stems or on the bases of tree-ferns along the watercourses. In the rather light forests of North Auckland *T. elongatum* and *T. humile* are almost invariably in close association on the banks of watercourses.

Four out of the seven New Zealand species of *Trichomanes*—viz., *T. Lyallii*, *T. venosum*, *T. Colensoi*, and *T. humile*—are exceedingly delicate and slender plants, which are unable to modify the frond-form by stunting or imbrication, and probably on this account are confined to such low epiphytic or rupestral stations as allow them to adopt the mat growth-form. All the New Zealand species of *Trichomanes* with the exception of *T. reniforme* occupy a restricted station.

B. *Description of Two Selected Localities.*

The above account of the species and of the associations in which they occur is based upon detailed field-notes taken in a large number of localities throughout Westland. In order to gather together these facts I now propose, before leaving this part of my subject, to give a description of the Hymenophyllaceae of two selected localities—viz., Mount Greenland, Ross, and the Otira Gorge (see map 2, on page 579).

Mount Greenland may be considered as the well-defined, heavily forested block of high land, outlying from the main ranges, rising immediately at the back of Ross, and thus not far from the coast-line, and encircled by the Mikonui and Totara Rivers. Its base is no more than 100 ft. above sea-level, and its long flat summit, 2,970 ft. in height, rises a little above the forest-line, so that it presents a favourable opportunity for the observation of the effect of increasing altitude upon the distribution of the Hymenophyllaceae, and of the difference in the humidity of the gullies and of the spurs and ridges.

The lower flanks and the larger valleys show only the characteristic lowland associations—viz., *H. dilatatum*, *H. scabrum*, and *T. reniforme* on horizontal boughs and tree-trunks; *H. ferrugineum* and *T. venosum* on tree-fern stems; *H. australe* and *H. Tunbridgense* on tree-bases, and the latter also on mossy stones and fallen logs; luxuriantly growing *H. sanguinolentum* and *H. multifidum* as mid-epiphytes; *H. demissum* on the floor; *T. strictum* in sheltered terrestrial nooks; *H. flabellatum* and *H. rarum* pendulous from the inclined trunks and boughs of the larger trees; and *H. Armstrongii* abundant on the stems of *Quintinia*, and occasionally also on tree-ferns. Such of the species as can occupy a high epiphytic station —viz., *H. sanguinolentum*, *H. multifidum*, *H. Armstrongii*, *H. rarum*, and *H. flabellatum*—ascend in the gullies into the tops of the tallest trees. The above species are present in abundance up to an altitude of 1,000–1,200 ft., and my notebook shows that the only other species observed below this altitude was *T. Colensoi*, in a very occasional colony, although no doubt *H. villosum* would also be present in the tree-tops at the upper limits of this zone, and possibly *T. Lyallii* also on tree-bases here and there. *H. bivalve* is apparently absent from Mount Greenland.

The track to the summit traverses the southern flank of the mountain at an altitude of about 2,000 ft. The humidity of the forest on shaded flanks at these altitudes is undoubtedly higher than on north-facing hillsides, or even than on the hillsides at lower altitudes, on account of the frequent presence of the mountain-mists. Hence these shaded upland flanks will be favourable localities for such Hymenophyllaceae as occur

at these altitudes. Here the rata is the dominant tree, and its irregularly-growing trunk and large horizontal boughs are thickly covered with sheets of *H. multifidum* and *H. villosum*. *H. flabellatum*, *H. rufescens*, and *T. Lyallii* are most abundant in colonies on the bases of the old rata and totara trees. The kawhaka is also present with *H. Malingii* upon its trunk, and *H. Armstrongii* is abundant on the stems of *Quintinia*. None of the typically lowland species occurs at these altitudes. These upland species are all present to the highest altitudes at which large trees are to be found, but it is noticeable that at about 2,200 ft. (this altitude varying according to whether the particular locality is a ridge or a flank) *H. multifidum* exchanges the epiphytic for the terrestrial station, and at the same time adopts its mountain form. *H. villosum*, *H. Malingii*, and *H. Armstrongii* at these altitudes are the only true epiphytes, the other species mentioned keeping to sheltered places at the very bases of the trees. Above 2,600 ft. the forest is only shrubby, and *H. multifidum*, *H. villosum*, and *H. Armstrongii* are alone present in their characteristic stations. The summit is clothed with scattered silver-pine, *Leptospermum*, and subalpine shrubs. Here, in a very stunted form, *H. multifidum* occurs in the heart of the larger grass-tussocks, and in moss under the shrubbery. On other outlying mountains lying nearer the main ranges *H. villosum* ascends with *H. multifidum* above the forest zone, the latter keeping to sheltered places in moss under rocks, but the former occurring commonly as an epiphyte on the lower moss-covered boughs of the shrubs.

A very deep sheltered ravine (Cedar Creek) descends from the shoulder of Mount Greenland into the upper Totara River, and the comparison of the species to be found here from bottom to top with those on the adjacent spurs indicates well the difference in the distribution which always goes along with the difference between the constantly high humidity of ravines and the more variable humidity of the less-sheltered spurs and ridges. Up to about 1,200 ft. the lowland species are commonly present in all parts, though along the creek-bed *H. dilatatum*, *H. scabrum*, and *T. reniforme* climb in sheets over inclined large trees to a height of 30 ft., whereas on the spur they are confined to the lower boughs of shrubby trees. These same species, and also *T. venosum* and *H. Tunbridgense*, attain their highest altitude on the sides of the valley at 1,500 ft., but in the bed of the ravine occur quite luxuriantly, although infrequently, still higher. These limits for *T. venosum* correspond with those for the tree-ferns. I must add that this particular ravine was especially secluded, and that in the gullies on other mountains situated nearer the main ranges, and on the ranges themselves, the above-mentioned species have a somewhat less altitudinal range. Above 1,500 ft. the forest-covering of the spur becomes more open and the floor drier; the rimu, black and white pine, and the miro are absent, as also are the climbing *Rubus*, *Rhipogonum*, and *Freycinetia*. Only the upland and wide-ranging Hymenophyllaceae are here present—*H. demissum* on the floor; *H. rufescens*, *H. flabellatum*, and *T. Lyallii* on the bases of the larger ratas, *H. multifidum* and *H. villosum* on low boughs; and *H. Armstrongii* on the *Quintinia*, as well as on mossy stones. It was noticed that *H. rarum*, which so generally accompanies *H. flabellatum* and is a still less hygrophilous plant, was, outside the gullies, for some reason by no means frequent. *Lycopodium varium* is also present in large spreading clumps on the floor of the spur. In the bed of the ravine, however, there is a well-closed high canopy up to at least 2,000 ft. altitude, and the other forest-stories are also dense. The tall rata and kamahi trees are here clothed to their tops with *H. villosum* and *H. multifidum*, and with *H. rarum* and *H. flabellatum* in sheets over the lower third of their trunks.

Above 1,800 ft. the actual creek-bed is covered with a dense shrubbery of *Fuchsia*, *Olearia*, and *Gaya Lyallii*, as is generally the case in mountain-gullies, and the stems and limbs of these shrubs are thickly clothed with a long wet moss in which *H. multifidum*, *H. peltatum*, and *H. pulcherrimum* occur in the greatest profusion and luxuriance. *H. villosum* is abundant also in the upper branches, and *H. Armstrongii* wherever the heavy moss is lacking. On the sides of the ravine at this altitude none of the lowland species is to be found, but all of those just enumerated, along with *T. Colensoi*, *H. demissum*, and the upland species generally, occur abundantly on the ground and on fallen logs or as low epiphytes. The hygrophilous *Leptopteris superba* and *Blechnum nigrum* are also commonly present. These are the localities *par excellence* for the Hymenophyllaceae. The upper reaches of the Hohonu River, on the north side of the Taramakau River, where it descends from the range of the same name, and also the deep secluded gorges along the base of the main ranges, show the same profusion of filmy-fern growth, more especially at the altitudes at which the lowland and the upland species meet. In those parts of Cedar Creek just described the wetness of the ground and the profusion of hepatics and ferns is in marked contrast with the dryness and openness of the spur-floor at corresponding altitudes. From 2,200 ft. upwards in the creek-bed the small mountain form of *H. multifidum* becomes very abundant in the heavy moss on the creek-sides. At this level the gully begins to open out as it approaches the shoulder of the mountain, and the *Fuchsia* shrubbery gives place to low-growing silver and mountain pine. Higher still the plant-covering and the filmy-fern flora is as already described for these altitudes.

The other locality to be described is the Otira Gorge, which lies on the Westland side of the dividing range, its lower end at the Otira Railway-station, at an altitude of 1,255 ft., ascending to 3,038 ft. at the summit of Arthur's Pass. Here the rainfall is extremely heavy, although the number of rainy days is rather less than at the coast-line. Wind is frequent and strong, that from the east being dry and cold, and persisting sometimes for days at a time. Here, then, the restricting effect of the altitude upon the distribution of the Hymenophyllaceae will be re-enforced by the considerable fluctuations in the humidity due to the winds.

At the lower altitudes such characteristic lowland species as *H. dilatatum*, *H. scabrum*, *T. reniforme*, and *H. sanguinolentum* are only rarely present, being confined to the lower closely-forested portions of the lateral creek-valleys. Apparently none of the species which in the lowlands climb into the tree-tops can do so here. *T. venosum* occurs sparsely on the scattered tree-ferns, but *H. ferrugineum* is apparently absent. *H. Tunbridgense* also was not seen. *H. pulcherrimum* is not uncommon even in the more open creek-beds, where it may be found growing strongly as a low epiphyte in moss and humus with colonies of its prothalli and sporeling plants. It is evident that this species does not demand an especially humid atmosphere, and at the same time that it depends mainly upon root absorption for its water-supply. The presence of its prothalli in the humus in these localities is strong proof that this water-supply is always present. *H. bivalve* occurs as a low epiphyte more especially in the sheltered gullies, and *H. demissum* is abundant everywhere on the floor, ascending in shaded localities high up in the subalpine forest. The flanks of the mountains are covered with the rata-totara-kawhaka forest association, and on the bases of the trees *H. rufescens* and *H. flabellatum* are abundant. *H. rarum* is also to be found in this station, but on the shady sides of gullies rather than on the open flanks. As on Mount Greenland, this species seems to be more

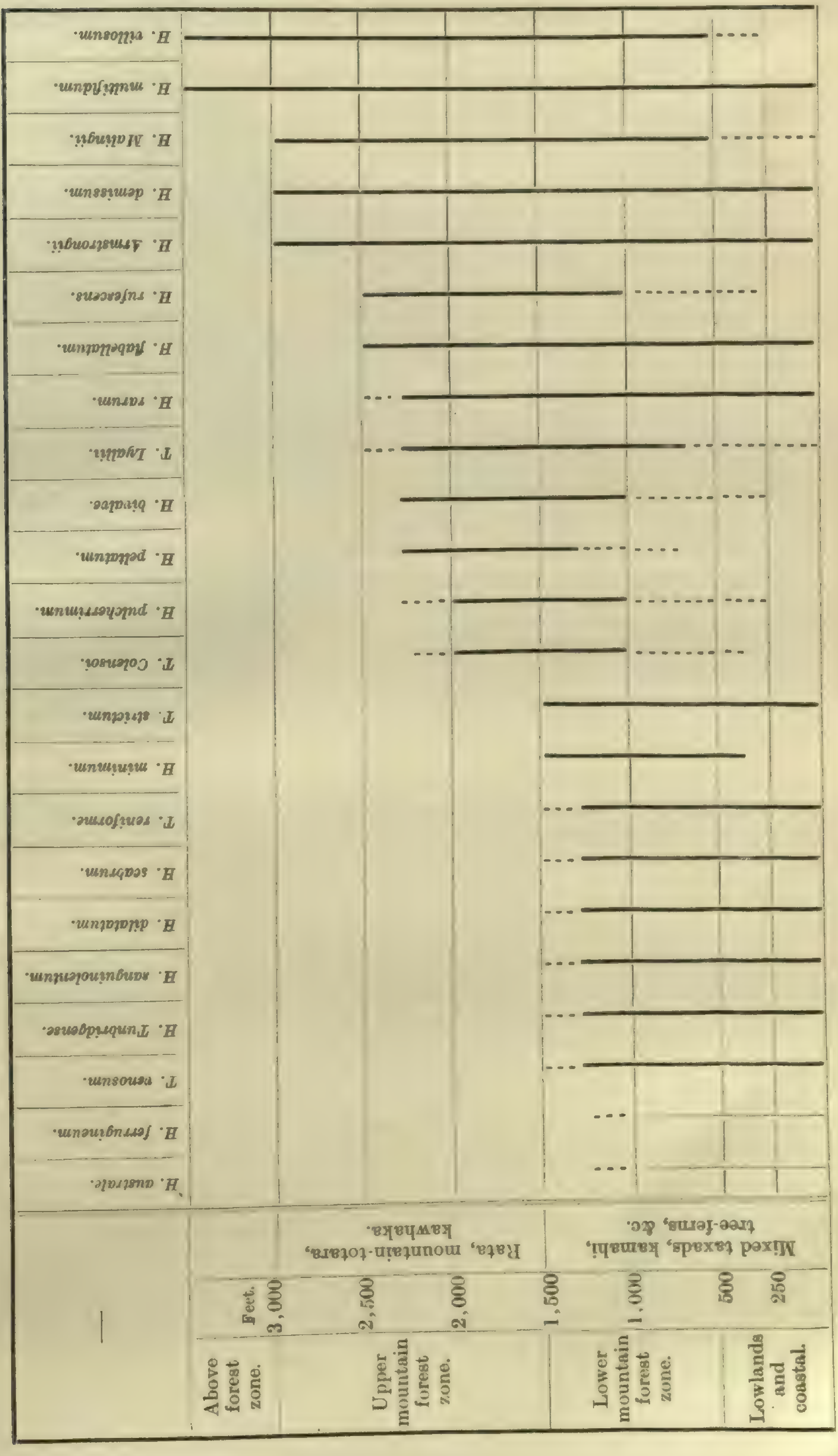
restricted in its distribution than *H. flabellatum*, although, as has been described above, it has a somewhat higher vertical distribution. *T. Lyallii* was not observed. *H. Malingii* occurs frequently on the kawhaka.

Throughout the whole Otira neighbourhood the two species *H. villosum* and *H. multifidum* are dominant. On the lower forest-clad hillsides the latter species keeps its mesophytic form and epiphytic habit, but on the open mossy rock-walls of the ravines and larger gullies it occurs with *H. villosum* in its stunted mountain form, the two species forming abundant and extensive sheets. In such situations the villous nature of the rhizomes and fronds of *H. villosum* is strongly developed (see Plate 59), and also the young fronds of *H. multifidum* are densely clothed with hairs. The other characteristic mat-formers, *H. rarum*, *H. Armstrongii*, and *H. minimum*, are occasionally to be found also on the damp walls of these narrow ravines. *H. villosum* ascends the forest-clad mountain-flanks higher than any other species, and it is noticeable that it keeps the low epiphytic in preference to the terrestrial station right up into the zone of subalpine scrub. The mountain form of *H. multifidum* is restricted to damp rock-sides and other especially damp mossy terrestrial stations wherever these occur, for, contrary to what is the case on Mount Greenland, the floor of the Otira forest generally at the higher levels seems to be too liable to drying for this species to occur there. The main Otira Gorge river-bed provides on its rocky sides very favourable situations for *H. multifidum*, and it here ascends with *H. villosum* to the summit of the pass. *Lycopodium varium* is also extremely common on rocks throughout the gorge. Along the open summit *H. multifidum* is only to be found on occasional damp rock-faces, but *H. villosum* is abundant everywhere as a low epiphyte on the *Olearia* and *Gaya* shrubbery, and in moss on boulders in the most exposed situations.

It is evident that the lowland Hymenophyllaceae do not ascend at Otira to as high a level as they do on Mount Greenland. It is the hairy upland species, such as *H. villosum*, *H. flabellatum*, *H. rufescens*, and *H. Malingii*, along with the mountain form of *H. multifidum*, whose young fronds also are hair-covered, which are here most in evidence, whose characteristic zone on Mount Greenland lies at a rather higher level. As has been indicated above, the difference is probably due to the occurrence of drying easterly winds at Otira, these being more negligible at Mount Greenland. In the neighbourhood of Otira it is noticeable that after several days of this wind certain of the epiphytic filmy ferns are very much shrivelled, and even the large-leaved shrubs show signs of wilting, but the ground-growing and the hairy filmies are little affected. *H. villosum*, even in its epiphytic station, is rarely shrivelled, although the fronds become much inrolled, and it is no doubt this capacity of withstanding drying that enables it both to preserve the epiphytic station at high altitudes and to ascend higher than any other species.

In the following Table C is summarized in diagrammatic form the altitudinal distribution of the Hymenophyllaceae in Westland. Since, in the case of not a few of the species, the altitudinal range varies somewhat from place to place, this table is merely intended to give a general comparative survey of the family in its differentiation into lowland and upland species, and into those which are restricted in their range and those which are more wide-ranging. The dotted continuations of the lines indicate the observed spread, beyond their characteristic altitudes, both of the lowland species upwards in sheltered mountain-gullies and also of the mountain species down into the lowlands.

TABLE C.


H. villosum.
H. multifidum.
H. Malingii.
H. demissum.
H. Armstrongii.
H. rufescens.
H. flabellatum.
H. rarum.
T. Lyallii.
H. bivalve.
H. peltatum.
H. pulcherrimum.
T. Colensoi.
T. strictum.
H. minimum.
T. reniforme.
H. scabrum.
H. dilatatum.
H. sanguinolentum.
H. Tunbridgense.
T. venosum.
H. ferrugineum.
H. australe.
Rata, mountain-totara, kawhaka.
Mixed taxads, kamahi, tree-ferns, &c.
Feet.
3,000
2,500
2,000
1,500
1,000
500
250
Above forest zone.
Upper mountain forest zone.
Lower mountain forest zone.
Lowlands and coastal.

C. *The Growth-forms and their Relation more especially to the Vertical Distribution.*

On account of the constantly high humidity in the lowland forests of Westland, the Hymenophyllaceae are there to be found at their optimum development. Throughout Westland the epiphytic station is, taking the family as a whole, the characteristic one, and a number of the species adopt a luxuriant pendulous habit with irregularly elongated fronds. This very luxuriance serves to throw into greater prominence two facts—viz., that certain thorough-going epiphytes are able to adopt a stunted and imbricated frond-form with a mat-like habit of growth, and in this state to flourish even in the forest-canopy and in other exposed stations, other epiphytic species being quite incapable of doing this; and, secondly, that certain terrestrial or low epiphytic species preserve the deltoid form of frond unmodified. The growth-form of each species and the extent to which it can be modified must thus be regarded as an important factor in the determination of its distribution. In the case of some of the species the growth-form will restrict the distribution, but with others the ability to modify it will act in the opposite direction.

(a.) *The Tufted Growth-form.*—This growth-form is known to be confined almost exclusively to certain species of the genus *Trichomanes.* The tufted species, *T. elongatum*, *T. strictum*, and *H. pulcherrimum*, do not occupy any considerable place in the physiognomy of their surroundings, since they cannot form sheets as do the creeping species. They occur generally singly, although a close search will often reveal the presence of a scattered colony which has originated from a single old plant. The two first-named species prefer secluded overhung situations where frequently no dripping water can reach the fronds. In the case of *T. elongatum*, whose frond-lamina is more extensive than that of *T. strictum*, the presence of epiphyllous mosses and hepatics, however, proves the constant wetness of the fronds, and shows that in its secluded station there must be considerable condensation of water-vapour upon the frond-surface. The root-system of both species is well developed and the stem-xylem is large, so that, when also the small number of fronds is considered, it must be concluded that these plants obtain most of their water, and certainly all their nutrient salts, by root absorption. In his laboratory experiments with Jamaican species Forrest Shreve (26, p. 194) found that in the case of *T. rigidum*, whose growth-form is identical with that of the two species here considered, the extremely low water-loss from surface-dry leaves in a very moist atmosphere could not be met by root absorption. At the same time, he states that no other Jamaican species, even the most hygrophilous, behaved in this way, and he is inclined to find the explanation of it in *T. rigidum* in the fact that the lateral walls of the cells of its frond-lamina are greatly thickened and that thereby the rapid passage of water outwards from the veins is hindered. These tufted terrestrially-growing species of *Trichomanes* show no marked modification in the frond-form in the way of increasing the frond absorption, beyond the facts, previously mentioned, that there is a very slight zone of multi-layered lamina in the frond of *T. elongatum* where the larger veins converge, and also that the frond-lamina of this species is more extensive than that of *T. strictum*, so that in this respect they may be regarded as representing more or less nearly the original frond-form of the family. At the same time, it is, of course, possible that in other ways they may have departed from the primitive character of the family in accordance with their specially hygrophilous habits. Their growth-form restricts

them to situations where they can root in the soil and where this is continuously damp.

H. pulcherrimum is a tufted species which in Westland occurs altogether as an epiphyte. Its fronds are large, with a much greater total extent of lamina than in the two last-named species. Moreover, the frond-form is not fixed, as in the two others, but is readily modified into a pendulous, much-elongated form. Pendulous fronds are frequently bathed in rain-water which has splashed from the leaves of the trees or has run down over the surface of the bark and through the mass of moss and humus in which the plant is growing, so that this species is not so dependent upon root absorption as the two above mentioned. Its root-system is, however, well developed, and it is confined to forks of trees and other epiphytic places where there is a considerable accumulation of humus. It has been indicated above in the paragraph dealing with Otira that this species probably, after all, demands a constant root supply of water rather than a constantly high atmospheric humidity, although, of course, it will attain its most marked luxuriance if the latter factor be also present. It would appear that *H. pulcherrimum* cannot occur on the flat floor of the forest as does *T. strictum*, for it has departed from the typically erect terrestrial habit; nor can it descend to the lowlands, for there the branches of the trees do not, as a rule, carry much moss and humus, and are liable to occasional drying.

(b.) *The Open-creeping Terrestrial Growth-form.*—The representatives of this class are *H. demissum* and *H. bivalve.* The fronds of these species are strongly erect or somewhat decurved, and are of an invariable deltoid form, and hence of limited size. The rhizome and root-system is well developed. Among the Hymenophyllaceae the typical epiphytic species show special frond-modifications in accordance with this station in the way of the extension of the lamina, and especially in the departure from the erect deltoid form of frond of limited size; but such modifications are altogether lacking in *H. demissum* and *H. bivalve*, even when they become low epiphytes, as the latter frequently does, and the former occasionally. It may well be that the inability to modify the frond-form in order to extend its function of absorption prevents these two species from becoming thorough-going epiphytes. Of the two, *H. demissum* possesses the greater extension of lamina, so that it is not obvious why this species should show the much less marked tendency to become epiphytic. The adoption of the creeping habit certainly makes it possible for a plant to take up an epiphytic station.

(c.) *The Open-creeping Epiphytic Growth-form.*— The small epiphytic species are considered by themselves below. In the species of this third class there is usually a modification of the frond in accordance with the epiphytic habit. *H. australe* is a good example of the transition from the terrestrial to the epiphytic station, occurring in Westland always at the bases of large trees and climbing upwards a few feet. It retains the erect deltoid form of frond, but shows a considerable extension of the lamina by means of the broad crisped wings. It occasionally is pendulous, and the fronds then show a marked increase in length. *H. atrovirens*, which is probably a form of this species, is erect with deltoid or lanceolate fronds when terrestrial, but pendulous and elongated when growing on vertical rock-faces in sheltered ravines. The rhizome and stipe of *T. reniforme* is comparatively stout, but, with the exception of *H. Malingii*, the frond shows the greatest degree of modification in the New Zealand family. The

study of the sporelings of this species shows that the completely webbed character of the mature frond, and possibly also the multi-layered condition of its lamina, are to be regarded as special modifications. Another stoutly-growing species with considerable frond-modification is *H. dilatatum.* Here the extent of lamina is certainly, taking into consideration the size of the frond, the greatest in any of the New Zealand species. *H. scabrum*, *H. sanguinolentum*, and *H. multifidum* also show a large frond-development in the pendulous state, the first-named attaining an extreme length of 2½ ft. to 3 ft. In the mid-epiphytic station in the lowland forests the lateral pinnae of the fronds of *H. sanguinolentum* and of *H. multifidum*, as well as the main rhachis, frequently tend to elongate into tails. *H. villosum*, although a characteristic epiphyte, shows a poor extent of frond-lamina, and the frond preserves more or less invariably the erect deltoid form. To this statement must be added the fact that it is a mountain and not a lowland plant, and that whereas the mid-epiphytic station in the lowland forests enables the species to make the most use of atmospheric water by frond absorption, the same station in the mountain-forests, especially at such elevations as *H. villosum* can ascend to, where the atmospheric humidity is more variable, is of value rather on account of the water-supply in the damp mossy clothing of the tree-branches. When, however, it occurs as a low epiphyte at the bases of the ranges, in which localities and station there is a more constantly high atmospheric humidity, its fronds frequently show a well-marked tendency to an elongation of the main rhachis, and they may also be pendulous.

The question arises regarding the open-creeping, strong-stemmed epiphytes such as *H. dilatatum*, *H. scabrum*, and *T. reniforme*, which in creek-beds at the base of the ranges can occur rupestrally and adopt a more erect habit of growth, as they do also very generally in the more light forests of other parts of New Zealand—why do they not also occur on the floor or on fallen logs in the lowland forests of Westland? It may be that with such species the need for light in the heavy dense forests causes them to keep to the epiphytic station, and it is to be noted that where in Westland they do occur terrestrially at higher altitudes it is in such less-shaded localities as creek-beds.

As has been mentioned, the fronds of the pendulous epiphytes will frequently be bathed in water which has soaked down from the branch or trunk on which they are growing. No doubt the fronds also absorb nutrient salts in this way. In his experiments already quoted, Forrest Shreve (26) showed that the ground-growing, more hygrophilous Jamaican species do not absorb uncondensed atmospheric moisture by the fronds, but that the high epiphytes do, although the actual amount so obtained is small. The rhizomes and roots of the large-growing mid-epiphytic New Zealand species are not usually embedded in moss, but simply cling closely to the tree-surface, so that there is no considerable root water-supply available for them. *T. reniforme*, whose fronds are generally rigidly erect, prefers the larger surfaces of tree-trunks, but the other species of this class, with the exception of *H. australe* and *H. villosum*, prefer the under-side of horizontal boughs from which they can hang free.

(d.) *The Thin-stemmed Close-creeping Epiphytic Growth-form.*—There are a few species which show in the filiform nature of their rhizomes and stipes, and, in the case of certain species, in their hairy character, a still further modification in accord with the epiphytic habit. *H. flabellatum*, *H. rarum*, and *H. Malingii* are typical members of this class, and also certain of the smaller-growing species. They are always pendulous, the first two being

characteristically confined to the under-side of inclined trunks and large boughs, and they grow generally in close colonies. It is obvious that the thread-like stems of these species could not carry an adequate water-supply from the substratum even if this were available. On the other hand, there is a very large extent of lamina in proportion to the size of the frond, this being especially the case in *H. rarum;* while in *H. Malingii,* as has been noted, there is a very remarkable and effective frond-modification for the purpose of frond absorption. *H. ferrugineum* is also invariably pendulous with overlapping fronds in its station on tree-fern stems, and the rhizome and stipe is slender, though not so much so as in the three above-mentioned species.

It is significant that these four species, which are thus so dependent upon frond absorption, show withering in times of drought to a markedly less degree than do other epiphytic species. In the case of *H. Malingii* the nature of the frond-tissues readily explains this. It has been suggested that the peculiar colour of the fronds of *H. rarum* and *H. flabellatum* may possibly serve to mask the cell-protoplasm from excessive transpiration. *H. ferrugineum* is one of the hairy species. Its fronds are almost rusty-brown in colour owing to the dense clothing of stellate hairs on the margins of the segments and on the costae on both surfaces of the frond (see Plate 76). So closely do the hairs interlock that they cannot help but shield the lamina from air-movements. However, it must be remembered that this species is more restricted in its distribution than the other three, and is distinctly hygrophilous. *H. ciliatum,* which very doubtfully occurs in New Zealand, seems to be of much the same slender pendulous growth-form as *H. ferrugineum.* In this species also the margins of the segments, and to a less extent the costae, are clothed with stalked stellate hairs. Forrest Shreve notes (26, p. 193) that the three Jamaican hairy species of *Hymenophyllum* are the most resistant to drying and insolation of any. From experiments he concludes that the cavities of the frond-hairs have no great importance as reservoirs of water. He observes also that under natural conditions these hairy fronds do not often become saturated with rain-water, a fact which I may state is true also of the New Zealand hairy species. However, it may well be that the hairs hinder transpiration, and this will certainly be so in the case of the densely-clothed young fronds. I may add that thick-walled colourless unicellular bristles are borne in large numbers on the margins of the prothalli of the terrestrial *T. elongatum,* and are especially in evidence overlapping their growing-points. Each arises from a single otherwise unaltered marginal cell. Whether the hairs in this case serve as a mechanical strengthening or for holding a film of water cannot here be stated. *H. flabellatum* is characterized by a dense woolly tomentum on the rhizome and stipe of the mature frond, and this on the young frond shields the lamina also. This will act as a protection for the growing parts of the plant, and hence may be considered of special importance with respect to the epiphytic station. In this connection it is to be noted that on the mountain-flanks this species may frequently be found showing the tomentum as a persistent although more or less scanty clothing on the rhachis and costae of the mature as well as of the younger fronds.

(e.) *The Mat Growth-form of the Small Species.*—The nine smallest species—viz., *T. Colensoi, T. humile, T. Lyallii, T. venosum, H. rufescens, H. Tunbridgense, H. peltatum, H. minimum,* and *H. Armstrongii*—are all creeping mat-formers, a growth-form which is, of course, very effective both in hindering transpiration through the overlapping of the fronds and also in holding water and humus against the roots. The stipe of *T. humile* and

T. venosum is flexible as well as slender, so that their fronds are pendulous and irregularly elongated. In this respect these two species are more modified than the others of this class. Occasionally, however, erect fronds of *T. venosum* may be found which are less modified from the deltoid form (see Plate 72). In especially humid localities the fronds of *H. peltatum* and *H. Tunbridgense* also may become pendulous and elongated. The tiny fronds of the other small species preserve a more or less rigid habit of growth, even when, as in *T. Colensoi*, *T. Lyallii*, and *H. rufescens*, they keep to overhung stations, and the fronds remain rigid and practically unmodified in form. Most of these small species are probably best interpreted as reduction forms. The frond of *H. rufescens* is typically deltoid, and it is to be noted that *H. flabellatum*, to which the other species is undoubtedly closely allied, also frequently adopts a very similar form in mountain stations.

The hairy covering of the fronds of *H. rufescens* and *T. Lyallii* probably acts as a protection against drying in the same way as has been suggested for *H. ferrugineum*, and thus plays a part in enabling these species to endure a somewhat more exposed position than such other mountain species as *T. Colensoi*. No doubt the base of large trees at the misty altitudes at which these two species abound is for the most part a sheltered and humid station; but the reason why they prefer high to low altitudes is best sought in the supposition that they are mountain forms of lowland plants.

In the case of all these small delicate species the mat is the natural growth-form when growing on surfaces of any extent, although *H. Armstrongii* and *H. minimum* are small enough to be able to bury their fronds in moss, and thus to spread as more open creepers on to the smaller surfaces of tree-branches. *H. peltatum* alone of these small species can become stunted with imbricating pinnae, and it is in this form that it occurs in exposed positions. It is certain of these small species which show, especially in their more exposed stations, the mat-form in the most pronounced state in which it is to be found in the family. Possibly the inability to shield the lamina by imbrication and inrolling of the pinnae is an important reason why such small species as *H. Tunbridgense* and the other typically low epiphytes of this class are so restricted in their vertical distribution.

(f.) *The High Epiphytic Stunted and Imbricated Mat Growth-form.*—The last growth-form to be considered is that illustrated by certain normally large-fronded species, which, on account of their ability to adopt the mat habit together with an extremely stunted and imbricated form of frond, accompanied in certain of the species by inrolling of the frond-segments, are able in the lowlands to endure high epiphytic conditions, and, in the case of two of the species, to exist in exposed subalpine stations. These are *H. sanguinolentum*, *H. multifidum*, *H. villosum*, *H. rarum*, and *H. flabellatum*. These species all occur commonly along with the small *H. Armstrongii* in the tops of the forest-trees in the lowlands, both in the heavy forest of the coastal flats and of the terraces, and also in the black-pine and white-pine stands of the river-flats, the latter of these localities being more exposed to the mountain winds. As has been noted, *H. villosum* does not occur below the middle lowlands.

H. villosum and *H. multifidum* are able to endure greater degrees of desiccation than the other species, as is shown by the fact that they alone flourish in exposed positions above the forest-line. As high epiphytes in the lowlands these two species and *H. sanguinolentum* show the stunting of the frond and imbrication of the pinnae with inrolling of the segments,

H. multifidum Swartz. Showing tree-top form (left), upper third of frond of mesophytic form (right), and mountain form (below). All nat. size.

Face p. 608.]

H. bivalve Swartz. × ⅔.

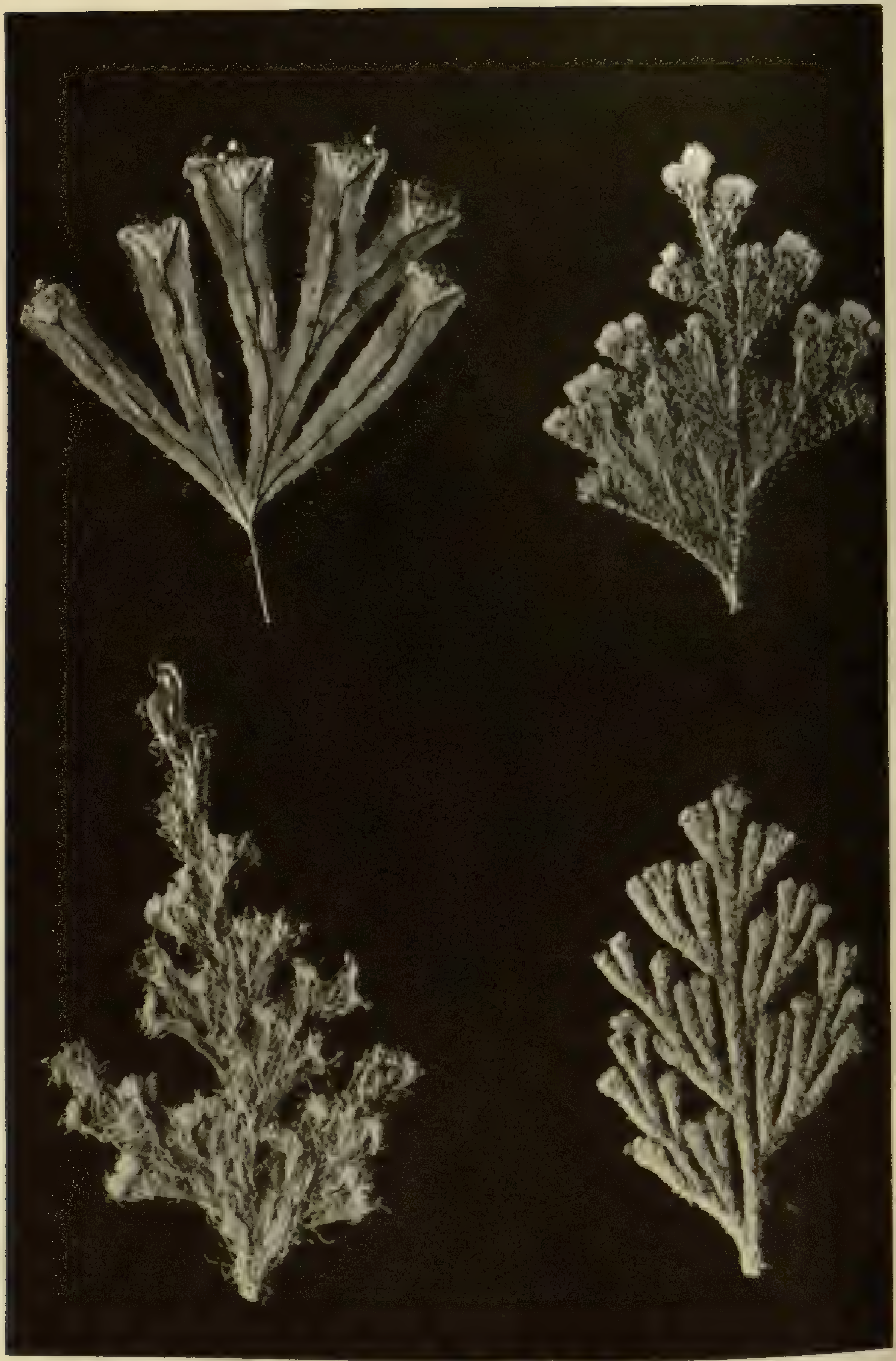
T. reniforme Forst. × ⅔.

T. venosum R. Br. Showing three forms. Nat. size.
T. Lyallii Hook. & Bak. (below). Nat. size.

T. Colensoi Hook. f. Showing two forms (above). Nat. size.
T. humile Forst. (below). Nat. size.

T. strictum Menz. × ⅞.

T. elongatum A. Cunn. × ½.



T. Lyallii Hook. & Bak. (left, above); *H. ferrugineum* Colla (right, above); *H. rufescens* T. Kirk (left, below); *H. Malingii* Metten (right, below). Portions of fronds showing hairs. All × 4

but they do not here adopt so characteristically the mat growth-form. On the other hand, the frond-segments of *H. rarum* and of *H. flabellatum* are apparently unable to inroll, but these two species keep their high epiphytic station by the imbrication of the pinnae along with the adoption of the close mat growth-form. For this reason they keep to the larger surfaces of the main trunk and of the larger limbs in the tree-tops in the lowlands, whereas the other three species creep out also on to the small branches. It must be noted also that as a high epiphyte *H. multifidum*, although much stunted, does not adopt the peculiar "mountain form," this being only found in its terrestrial station.

Above the forest-line, and in exposed subalpine localities generally, *H. villosum* and *H. multifidum* adopt the close mat growth-form. Of these two species the former can certainly exist in the more exposed positions, *H. multifidum* seeming to need always a damper, more shaded situation. Moreover, whereas the latter is here always rupestral, the former is frequently a low epiphyte, being then an open creeper in the moss. Possibly it is the possession of the villous clothing of the fronds and rhizomes which gives *H. villosum* the extra advantage, although it must be said that at these altitudes *H. multifidum* also shows this character, but to a much less extent. As a mountain plant the fronds of the last-named species are typically deltoid in form, and in the most exposed situations are strongly decurved so as almost to bury themselves in the mossy substratum.

As indicated previously, the significance of the imbrication of the pinnae, the inrolling of the frond-segments, and the stunting and overlapping of the fronds of these mat-formers lies in the fact that transpiration is thereby hindered, and probably also water is held against the frond-surface. Moreover, the underlying stratum of interwoven rhizomes and roots, and the accumulated humus of the dead fronds and of the moss, is able to hold water over considerable periods of drought.

D. *The Bearing of the Distribution of the Species upon the Subject of the Phylogeny of the Family.*

In the foregoing pages both the vertical and the altitudinal distribution of the various species has been considered. These facts will now be collected and their general bearing upon the subject of the phylogeny of the family discussed. The altitudinal distribution of the family has been summarized in Table C, on page 603.

Table D, on page 610, sets forth in diagram form the vertical distribution of the members of the New Zealand family as it is to be seen in Westland, the three species which do not occur there being also included for reference, their names being placed in parentheses. As the station in the forest adopted by a species varies very often with the particular locality, and is especially affected by the altitude, this table must be regarded as indicating the full vertical range of which each species is capable in Westland.

From this table the following generalizations can be made :—

1. The species whose fronds apparently cannot vary from the erect deltoid regular form of growth—viz., *T. strictum*, *T. elongatum*, *H. demissum*, and *H. bivalve*—are either altogether restricted to the forest-floor or have only to a very restricted extent acquired the epiphytic habit. *H. australe* and the allied *H. atrovirens* illustrate the beginning of the modification of the typical terrestrial form of frond along with the adoption of the epiphytic habit.

TABLE D.

	High epiphytic. Tops of forest-trees.	Mid epiphytic. Tree-trunks or horizontal boughs from 6 ft. to 20 ft.	Low epiphytic. Tree-ferns, tree-bases, or low mossy boughs up to 6 ft.	Low epiphytic. Rock-faces, boulders, or overhung banks.	Terrestrial. Forest-floor.
H. villosum.	—	—	—	—	—
H. multifidum.	—	—	—	—	—
H. sanguinolentum.	—	—	—	—	
H. Armstrongii.	—	—			
H. rarum.	—	—	—	—	
H. flabellatum.	—	—	—		
H. Malingii.	—	—	—		
T. reniforme.	—	—	—	—	
H. scabrum.		—	—	—	
H. dilatatum.		—	—	—	
H. pulcherrimum.		—			
H. australe.		—	—	—	
H. minimum.			—	—	
H. peltatum.			—	—	
H. Tunbridgense.			—	—	
H. ferrugineum.			—	—	
T. venosum.			—		
H. rufescens.			—		
T. Lyallii.			—		
H. bivalve.			—	—	—
H. demissum.			—	—	—
(*T. humile.*)			—	—	
(*H. atrovirens.*)				—	
T. Colensoi.				—	
(*T. elongatum.*)					—
T. strictum.					—

2. The smallest species of all—viz., *T. Colensoi*, *T. humile*, *T. venosum*, *T. Lyallii*, *H. rufescens*, *H. Tunbridgense*, *H. peltatum*, and *H. minimum*—in which frond-modification has taken place probably more especially in the direction of reduction, are restricted to special low epiphytic or rupestral stations. The tiny *H. Armstrongii* is an exception, in that it ascends into the tree-tops.

3. The species of *Trichomanes* have markedly a more restricted vertical range than those of *Hymenophyllum*, and occupy more specialized stations. The only exception to this is the large creeping *T. reniforme*, which, in the multi-layered condition of its frond-lamina, and in its ability to inroll the frond closely, possesses special powers of resisting desiccation.

4. The species which show most characteristically the epiphytic habit are those which have acquired, by elongation of the main rhachis and sometimes of the primary pinnae of the frond, or by extension of the lamina into wings, the greatest extent of frond-surface for the purpose of frond absorption. These are *H. dilatatum*, *H. scabrum*, *T. reniforme*, *H. flabellatum*, *H. rarum*, *H. sanguinolentum*, *H. multifidum*, *H. pulcherrimum*, and the peculiar *H. Malingii*. Two exceptions to this statement are the mountain species *H. villosum*, whose epiphytic station under the variable atmospheric humidity conditions of high altitudes is of value, probably, mainly on account of the damp mossy clothing of the tree-branches, and *H. Armstrongii*, whose tiny fronds are buried in and wetted by even the thinnest moss substratum.

5. The species which possess the greatest vertical range are those normally large-fronded epiphytes which are able to modify the entire growth-form by stunting of the frond, imbrication, and inrolling of the frond-segments, and by growing in close mats, and which are enabled through the possession of one or more of these modifications to flourish in the tree-tops. These are *H. multifidum*, *H. sanguinolentum*, *H. villosum*, *H. rarum*, and *H. flabellatum*. *H. Armstrongii* has the same wide range, and, as has been indicated, is the only one of the small-growing species able to ascend higher than a low epiphytic station. None of the hairy-fronded species are high epiphytes, for *H. villosum* is only really villous at high altitudes, outside of the forest, and *H. Malingii* keeps to the low or mid epiphytic station. The frond of *H. flabellatum* also only becomes villous at high altitudes.

6. Comparison of Table D (page 610) with Table C (page 603) shows that the species which have the greatest vertical range in the forest are also those which have the greatest altitudinal range in the district. There is, however, one exception to this—viz., *H. sanguinolentum*, which does not ascend above 1,500 ft.; and there are strong reasons for regarding *H. villosum* as the mountain form of this species. The species which occupy in the lowlands and in the lower mountain-ravines a high epiphytic station become on the flanks of the mountains low epiphytes or even terrestrial plants.

These conclusions have a certain bearing upon the larger question of the phylogeny of the family. With regard to this it will be necessary first briefly to consider other sources of evidence.

From the comparative study of the spore-output of the different members of the family, Bower (4) concludes that the sporangia are larger and the contained number of spores higher in *Hymenophyllum* than in *Trichomanes*, a fact which points to the former genus being nearer the Simplices than the latter. The smaller number of spores per sporangium in *Trichomanes* is compensated for in that genus by the extraordinary growth of the receptacle

with continued formation of sporangia, a character which is certainly a specialized one. It is noteworthy that this character is strongly developed in *H. multifidum*, and not infrequently also in *H. minimum*, but to a small degree in *T. reniforme.* It is completely absent in *T. Lyallii*, a species which is regarded as intermediate between *Hymenophyllum* and *Trichomanes*, and whose prothallus, it may be added, is of the strap-shaped form characteristic of the former genus.

The prothalli of *Trichomanes* are known to be of a filamentous nature, though in some species I have found—as, for example, in *T. reniforme*, *T. Lyallii*, and *T. elongatum*—that the filamentous stage is short, and is early replaced by a flat multicellular expansion. It was at one time considered that this filamentous character is primitive, but the consensus of opinion is certainly now in favour of regarding it as secondary.

In his comparative study of the stem-anatomy of the Hymenophyllaceae, Boodle (2) concludes that with regard to this character *H. dilatatum*, *H. scabrum*, and *T. reniforme* are the most primitive in the existing family, and that the species of *Trichomanes*, on the whole, show greater modification of this type of stelar anatomy by reduction, or in some cases by amplification, than do the species of *Hymenophyllum*.

Other evidence has been adduced in favour of regarding these same three species as representing the least-specialized part of the family. They are known to have a frond-lamina which is several cells in thickness, whereas in the family as a whole it is only one cell in thickness, which latter character is regarded as a modification adopted in accordance with the hygrophytic habit. Not only do these three species in this respect stand apart from the rest of the family, but Bower has shown (3) that in the basal parts of the adult fronds of *T. reniforme* and *H. dilatatum* the segmentation at the edge of the lamina is by alternating oblique walls, as in ordinary leptosporangiate ferns, and not by repeatedly transverse walls, as is usual in the Hymenophyllaceae.

It is found that the filmy habit in the family as a whole is accompanied by structural reduction in other organs, pseudo-veins, representing reduced veins, being present in the fronds of some small species of *Trichomanes*, and roots being very rudimentary, or in some cases altogether absent in others. As has been mentioned, Boodle found a very simple stem vascular structure more especially in the small species of *Trichomanes*, which he regarded as occupying the last place in a reduction series.

Generally speaking, then, the whole family is to be considered as much simplified in accordance with its hygrophily, and this simplification has proceeded, hand in hand with certain other features in specialization, further in *Trichomanes* than in *Hymenophyllum*.

It remains to be seen whether or not the facts concerning the New Zealand species brought forward in this paper throw any further light upon this subject.

It has been shown that the multi-layered condition of the frond-lamina in *H. dilatatum*, *H. scabrum*, and *T. reniforme* is developed secondarily in the ontogeny, being found in the fronds of the sporeling plants only immediately alongside the veins, and not being referable to the activity of the marginal meristem. This seems to suggest that the possession of this character must not necessarily be adduced in favour of regarding these species as the most primitive in the family. However, Bower (4, note at bottom of p. 65) has pointed out that *T. reniforme* is the one species of *Trichomanes* which has a large output of spores per sporangium.

Although these three species obviously show specialization in frond-form in the way of extension of the lamina and departure from the strictly deltoid form in accordance with the epiphytic habit, they have not become so thoroughly modified as have the thin-stemmed and invariably pendulous species of *Hymenophyllum*, or as have, on the other hand, the small reduced species of *Trichomanes*. Moreover, the extent of specialization in these three species has not apparently resulted in any great modification of the stem vascular system. Nevertheless we might expect to find species in the family representing more nearly still the primitive stock.

Emphasis has been laid upon the fact that the terrestrially-growing *H. demissum* and *H. bivalve* possess the deltoid frond-form which certainly seems to be the least modified in the existing family. Boodle also has shown (2) that the stem vascular anatomy of *H. demissum* corresponds very closely with that of the above-named three species. I would suggest that *H. demissum* and *H. bivalve* give a better idea as to the primitive stock of the family than does the *H. dilatatum* group. If this is so, then we may perhaps regard this primitive stock as possessing a much-dissected form of frond with little extension of lamina.

Boodle (2) found that the stem-structure of several erect tufted species of *Trichomanes* differed from that of the *H. dilatatum* group only in so far as it showed a solid circular core of metaxylem intermixed with parenchyma, instead of a more or less broken xylem cylinder enclosing the centrally placed protoxylem and parenchyma. He concluded that with regard to the stem-anatomy the upright tufted species are not far removed from the *H. dilatatum* group, and he states that it is doubtful whether they are to be regarded as more primitive than the latter or as more specialized. The suggestion that these tufted terrestrial species represent the original stock most nearly of all, not only in their stem-anatomy but also in their growth-form, is one which should be seriously considered. The family as a whole is much modified in accordance with the function of frond absorption or in the way of reduction, and such tufted species as *T. elongatum* and *T. strictum* show such modification to the least extent with respect to their general growth-form and frond-form. It seems natural, therefore, to conclude that their stelar structure will also be little modified, while, on the other hand, we might well expect that the creeping *H. demissum* with its larger number of fronds and consequent less dependence upon the root and stem vascular system, and still more the species of the epiphytic *H. dilatatum* group with their much greater powers of frond absorption, would show an appreciable reduction in the amount of stem-metaxylem.

The generalization that, on the whole, the species of *Hymenophyllum* seem to have diverged from the primitive stock in one direction and the species of *Trichomanes* in another, and that this primitive stock can still be traced in the modern family, is in accordance with what has been set forth in this paper with regard to the general biology of the New Zealand species. The species of *Trichomanes* keep nearer the floor and, with the exception of *T. reniforme*, are either much reduced or remain for the most part unmodified, whereas the species of *Hymenophyllum* nearly all show, though in different degrees, a particular type of modification which has resulted from the epiphytic pendulous habit.

With regard to the altitudinal distribution, I have noted that in the New Zealand family several pairs of species are found concerning which not only the complementary regional distribution of the two members of

each pair, but also the fact that at intermediate altitudes intergrading forms are to be found which link up the two members in every important particular, point to one member in each of these pairs being a specialized form of the other. Additional data bearing upon this point will be noted in my second paper. These pairs of species are—*H. sanguinolentum* and *H. villosum*; *H. flabellatum* and *H. rufescens*; *H. australe* and *H. atrovirens*; *H. Tunbridgense* and *H. peltatum*. It is to be further noted that *H. villosum*, *H. rufescens*, and *H. atrovirens* are endemic to New Zealand. I must add, however, that in the case of possibly all of these pairs both members are sometimes to be found side by side at intermediate altitudes, each presenting its distinctive characteristics. Here, then, it seems there is direct evidence of the evolution of the family taking place in accordance with variation in the climatic conditions. Whether or not such derived forms are truly "fixed" must be determined by properly-carried-out experimental cultivation, or perhaps better still by wide and detailed field-study. This, of course, touches upon the much wider question as to which of the mountain or other highly specialized species of a country, such as, for example, New Zealand, are true-breeding species, or whether, rather, they are not true species at all, but merely "forms" which preserve their distinctive character only so long as they remain under the control of certain environmental conditions. A family, such as the Hymenophyllaceae, or a particular species, which is in a highly plastic condition, can be expected to afford examples which should be of great interest and importance in the consideration of evolutionary problems. One other such example must be referred to. *H. multifidum* in Westland is to be found in two distinct forms, the one when epiphytic and the other when terrestrial at higher altitudes. In the lowlands this species, as has already been described, has a wide vertical range and shows itself capable of great corresponding variation in its form, but even when most stunted as a high epiphyte it never exhibits the form which it has as a terrestrial mountain-plant. This terrestrial variety is very distinct, and it may even be found occasionally in more lowland situations growing in moss on the ground in exposed places. It might therefore be concluded that the mountain form is either a "fixed" variety of the lowland or that it is the direct result of the terrestrial habit. However, at the base of the ranges one may sometimes find the lowland form growing more or less erect on mossy boulders in various stages of stunting, in at least one instance my notes recording the fact that both the lowland and the mountain form were existing side by side in such a station; and also, at higher altitudes, where the mountain form is most abundant on the floor and the other altogether absent, one may find on especially sheltered and overhanging banks fronds of this species showing every gradation between the two forms. Also, although the mountain form is almost invariably restricted to the terrestrial station, it may be found occasionally at high altitudes in especially damp localities climbing shrubby trees to the height of 6 ft. to 8 ft. L. Cockayne experimentally cultivated plants of this species (which showed the extreme decurved deltoid and strongly inrolled mountain form) which he had brought from the exposed summit of the subantarctic Auckland Island. He states (8, p. 267), "Plants . . . cultivated in the moist chamber of the Canterbury College Biological School have their new fronds not in the least degree curled up, and of a bright green, contrasting strongly with the almost black curled fronds. Such young fronds are at first erect, with their

pinnae plagiotropous, but finally the stipes bend so as to bring the whole surface of the frond into a horizontal position. . . . By March, 1904 [*i.e.*, nine months after the beginning of the experiment], the new fronds of the curly leaved form were identical with those of the type."

It can only be concluded from these apparently conflicting lines of evidence that not only are the epiphytic and the terrestrial stations able to produce very distinct effects upon the growth-form of this species, but also that it is in such a highly plastic condition that it responds quickly to smaller changes in the humidity and other growth-conditions than attract our observation.

In connection with the subject of the vertical distribution of the species brief reference must be made to the fact that the general epiphytic flora of the forest tree-tops in the Westland lowlands provides a very good indication of the nature of the climatic conditions which the six high epiphytic species of *Hymenophyllum* are able to endure. I have found that throughout the lowlands the high epiphytic flora, in addition to this group of filmy ferns, is made up almost exclusively of the orchids *Dendrobium Cunninghamii*, *Earina suaveolens*, *E. mucronata*, *Sarchochilus adversus*, and *Bulbophyllum pygmaeum*, certain species of *Polypodium* — viz., *P. diversifolium*, *P. Billardieri* (= *P. australe*), and *P. grammitidis*—*Cyclophorus serpens*, and *Asplenium flaccidum*. Other plants as well occur in the tree-tops, such as *Lycopodium Billardieri* and species of *Astelia*, although these are by no means so frequent as those above mentioned. These all show striking structural features in correspondence with the variable conditions of the tree-tops, but such modifications are completely lacking in the high epiphytic Hymenophyllaceae which withstand those conditions by the adoption of the mat growth-form and by the imbrication of the fronds alone. It must be added that the above-mentioned epiphytic orchids and ferns, &c., in spite of their xerophytic characters, tend to adopt the rupestral habit in the less wet districts of New Zealand, and are more or less absent from the dry southern-beech forests of the Eastern Botanical Districts, showing that the tree-top conditions in the Westland forests are by no means severe. Miss K. M. Curtis (10) has described the special xerophytic features in the anatomy of the New Zealand epiphytic orchids. The following extract is taken from the summary at the end of her paper: "The velamen consists of one row of cells in *Bulbophyllum pygmaeum* . . . and two or three rows in *Sarchochilus adversus*. The number in the two species of *Earina* and in *Dendrobium Cunninghamii* is more variable, ranging from three to five or more . . . A great number of spirally thickened water-storage cells are present in the cortex of the root of *Sarchochilus adversus;* they are also to be seen, though less frequently, in the two species of *Earina* . . . The leaves of *Bulbophyllum* are succulent . . . pseudo-bulbs are present (consisting of large spirally-marked water-storage cells and small assimilatory cells) . . . The leaf of *Sarchochilus* is very succulent." The high epiphytic polypodies and *Asplenium flaccidum* are also structurally adapted for this station both in the thick fleshy nature of their stems and in the succulent or coriaceous character of their fronds. The fronds of *Cyclophorus serpens* are an extreme example of this. They are very thick and fleshy, the palisade water-tissue being up to eight or nine cells in thickness, and the under surface, as also, though to a somewhat less extent, the upper surface, being densely clothed with a tomentum of closely interlocking stellate hairs. The epiphytic

Lycopodium and the Astelias are also well adapted for their station. The delicate nature of the frond-lamina of the high epiphytic Hymenophyllaceae, and the complete absence of any water-storing tissue, frond-tomentum, or cuticle, is in striking contrast to the structural modifications in the other high epiphytes.

As a result of his investigations into the physiology of the Jamaican Hymenophyllaceae, Forrest Shreve concludes (26, p. 208) that the xerophily of the epiphytic species "resides not at all in their structure, but in the capacity of the protoplasmic utricle to withstand the removal of the sap which is its source of water and nutrient salts." The facts with regard to the New Zealand epiphytic species go to show that this statement must be somewhat modified and amplified before it can be applied to the family as a whole. The frond of *H. Malingii* shows a truly remarkable structural modification, even although this species occupies only a mid-epiphytic station. It is possible that the multi-layered condition of the fronds of *H. dilatatum*, *H. scabrum*, and *T. reniforme* is to be regarded as a recent modification rather than as a primitive feature. But a most important and effective modification in accordance with the epiphytic station is that which takes place in the growth-form, and it is probable that further study of the family will show that elsewhere also this is partly responsible for the wide vertical and altitudinal range of this hygrophilous family.

General Conclusions.

1. The distribution of the New Zealand Hymenophyllaceae is best studied in Westland, for the following reasons: (*a*) Nearly all the species are there present in abundance; (*b*) the constantly high humidity of the forest-interior enables them for the most part to adopt the epiphytic station; (*c*) the presence of only one type of forest reduces the question of their regional distribution to the simple one of the effect upon the family of altitude alone; (*d*) the effect of altitude upon the plant-covering generally is known to be more marked in the latitude of Westland than farther north.

2. In Westland a certain proportion of the species belong altogether to the lower altitudes, others, on the other hand, to the mountains, while a few range from sea-level to the subalpine forest, and two—viz., *H. villosum* and *H. multifidum*—extend into subalpine altitudes above the forest zone. The details of their altitudinal distribution are set forth in Table C, on page 603. This differentiation among the members of the family may be seen also in other parts of New Zealand, although farther northward it is modified by the increasing altitude attained by the lowland species and by the forest-covering generally.

3. The conclusions reached as to the vertical distribution of the species in Westland are set forth in Table D, on page 610. As will be shown in a subsequent paper, these conclusions are borne out by the behaviour of the species in other parts of New Zealand, except that in the drier districts, and also in the pure southern-beech forest where this occurs both under light and under heavy annual rainfall conditions, the epiphytic habit of the family generally is restricted in accordance with the more variable atmospheric humidity there experienced.

4. Those species which have the widest vertical range in the lowlands of Westland are, with the exception of *H. sanguinolentum*, those also which have, both in Westland and in other parts of New Zealand, the widest altitudinal range.

5. In Westland a large proportion of the species invariably form groups according to their habits. These groups can be recognized also in other parts of New Zealand, but differences between the members of the several groups are brought to light by their behaviour in lighter types of forest and under more variable climatic conditions, which differences are in some cases discernible also in their behaviour in the Westland forests.

6. A progression can be traced in the New Zealand family from species which are invariably terrestrially-growing to those which are invariably epiphytic, and this goes hand in hand with a progressive modification in the frond-form, in the relative extent of frond-lamina, and in the thickness of the rhizome and stipe, indicating a change from root to frond absorption. The species which occupy the most exposed positions both in high vertical and in high altudinal situations, or on exposed rock-faces, do so by means of their ability to adopt a stunted imbricated frond-form combined with a mat growth-form.

7. Certain mid-epiphytic species have progressed to a modification of the structure of the frond-tissues which undoubtedly aids them in retaining this station. Of these *H. Malingii* is the most notable example. It is suggested—and reasons are given—that the multi-layered condition of the frond-lamina in *H. dilatatum*, *H. scabrum*, and *T. reniforme* is an acquired and not a primitive character.

8. The species of *Trichomanes* are far more restricted in their distribution and in the ability to modify the frond-form than are those of *Hymenophyllum*, the only exception to this being *T. reniforme*, which in Westland is a characteristic mid-epiphyte, and which possesses a peculiar but fixed form of frond, and along with it the ability to inroll the frond closely.

9. The smaller species, both of *Trichomanes* and of *Hymenophyllum*, commonly adopt the mat growth-form even in their low epiphytic stations, this being especially marked in those of the former genus.

10. Four pairs of closely related species may be distinguished in the New Zealand family—viz., *H. sanguinolentum* and *H. villosum* ; *H. australe* and *H. atrovirens* ; *H. flabellatum* and *H. rufescens* ; *H. Tunbridgense* and *H. peltatum*. From the fact that in the case of each of these pairs the two members are more or less complementary in their altitudinal distribution, and also that intermediate forms are to be found at intermediate altitudes, it would seem that one member in each pair is a derived and possibly a mountain form of the other. The occasional existence of the two members side by side in the case of at least three of these four pairs, under apparently identical environmental conditions, makes more difficult the understanding of the exact relation of the two members to each other.

11. The suggestion has been put forward that in view of the fact that the greatest modification of the existing family so far as the New Zealand species are concerned, apart from the probable reduction in size of many species, has been in the direction of the adoption of the epiphytic habit with the tendency towards dependence upon frond absorption rather than upon root absorption, that therefore the more primitive growth-form and frond-form and stem-anatomy is to be looked for in the typically terrestrial members of the family, and possibly in the tufted species, rather than in any of the other members.

12. It is suggested that the inability of the larger epiphytic species to adopt to any noticeable extent in the lowland forests of Westland the terrestrial or low epiphytic station may be due to the need in the dark forest-interior of seeking the maximum illumination possible. Possibly this explains the fact that in Westland *T. venosum* and *H. ferrugineum*

are the only species which occur on tree-fern stems, although in lighter forests in other parts of New Zealand *H. rarum* and *H. flabellatum* quite commonly adopt this station, and other epiphytic species also occasionally.

13. The fronds of many of the New Zealand species can recover after a considerable degree of drying and shrivelling. The observations of the present writer with regard to this phenomenon relate only to the larger epiphytic species of *Hymenophyllum* and to *T. reniforme*. The typically terrestrial species and the low epiphytes, and also the small species generally, rarely are found shrivelled. Certain larger epiphytic species possessing filiform stems—viz., *H. rarum*, *H. flabellatum*, *H. Malingii*—are probably the most rarely shrivelled of the epiphytes, all apparently possessing special modifications for resisting desiccation. *H. villosum* can both withstand drying, and also recover from it when affected, to the greatest extent of all the New Zealand species.

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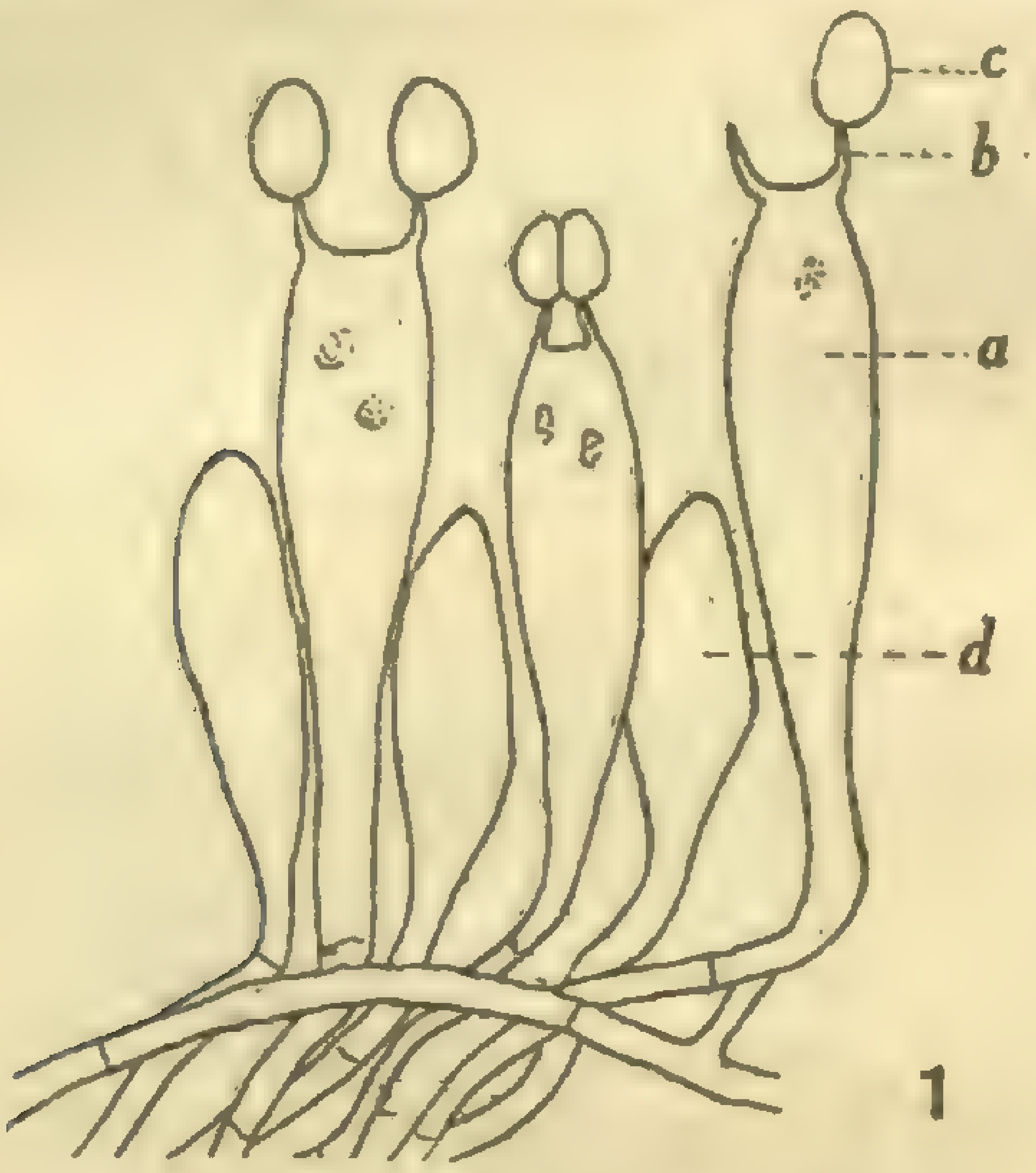
ART. 44.—*The Uredinales, or Rust-fungi, of New Zealand: Part I—Pucciniaceae, Tribe Puccineae (containing Descriptions and Illustrations of Seventy-five Species).*

By G. H. CUNNINGHAM.

[*Read before the Wellington Philosophical Society, 27th October, 1921; received by Editor 31st December, 1921; issued separately, 8th June, 1923.*]

Plate 77.

OF the three classes into which the fungi are divided by systematists (if we exclude the *Fungi Imperfecti*) the third class, the *Basidiomycetes*, is characterized by the fact that the spores are borne at the apices of sterigmata which are in turn borne on basidia (see figs. 1, 2).



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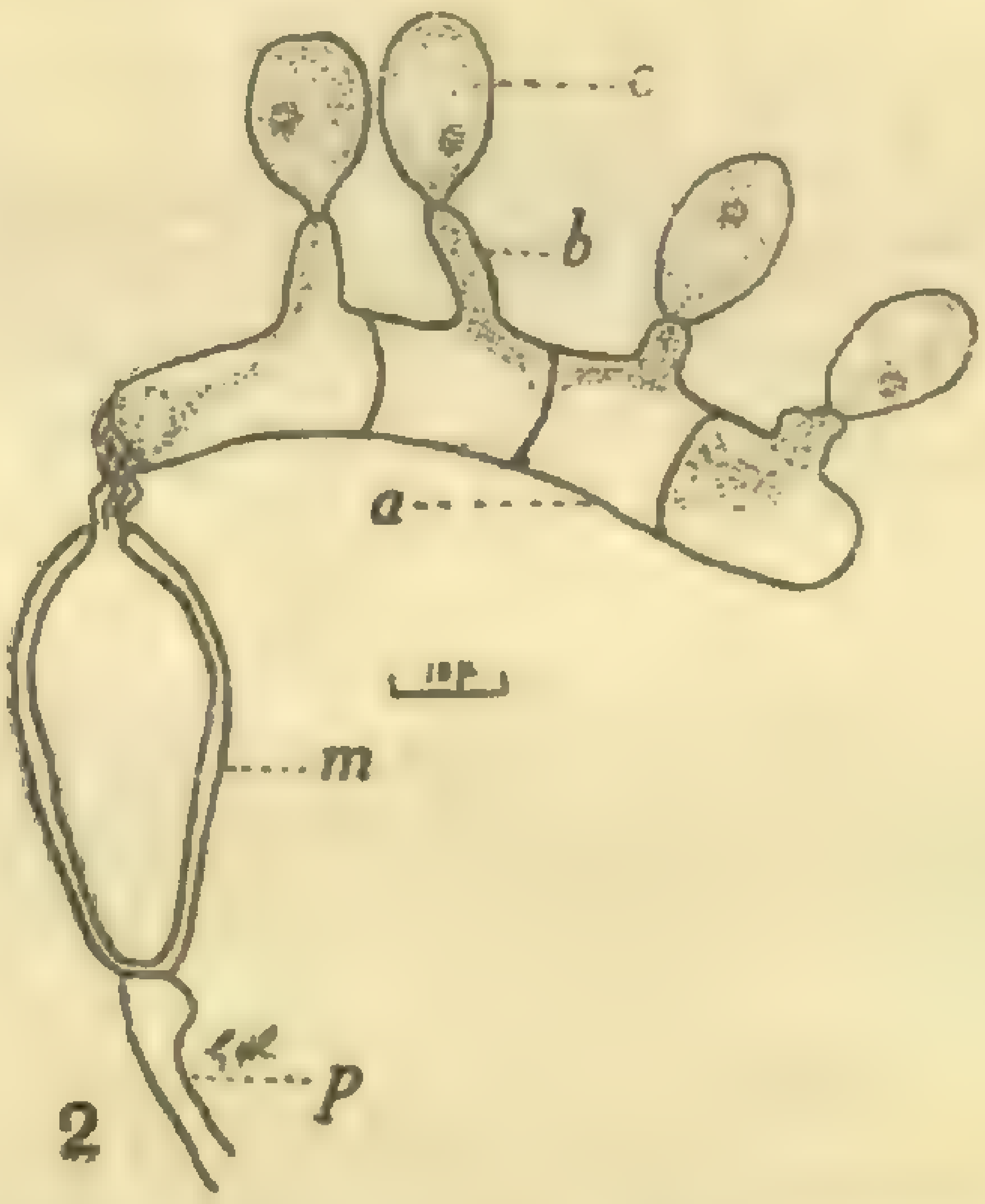

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FIG. 1.—Basidia of *Agaricus arvensis*: *a*, basidium; *b*, sterigma; *c*, basidiospore; *d*, paraphysis. × 500.

FIG. 2.—Germinating mesospore of *Puccinia novae-zelandiae* n. sp.: *a*, basidium; *b*, sterigma; *c*, basidiospore; *m*, mesopore; *p*, pedicel. × 500.

In this class are included the Uredinales, for the reason that the teleutospores (or final spores produced in the cycle of development) on germination produce basidia,* which become divided into four cells by cross-septa, each segment producing a sterigma on which a basidiospore† is borne (see fig. 2, *c*).

BIOLOGY.

All rusts are parasitic during their entire life-cycle, which consists of one or more spore-forms, occurring on the same (autoecious) or on different (heteroecious) host plants. The cycle is a complex one, and includes as many as five spore-forms. As a rule all species are highly specialized, and each can infect but one host plant; exceptions occur, however—*e.g.*, *Puccinia Malvacearum* Bert., which attacks plants belonging to many different genera of the family Malvaceae.

* Basidium = promycelium. The former is the more suitable term.

† Basidiospore: In accordance with the classification this is the correct term to use. These spores are commonly termed "sporidia" or "sporidiola."

As an illustration of the life-history of a typical rust, the cycle of the heteroecious species *Puccinia Caricis* Schroet. is given below* :—

In the early spring the teleutospore germinates and produces basidia, one from each cell; these grow out through the germ-pores, and, as they develop, the contents of the cells pass into them. Each basidium becomes four-celled when mature, and from each segment a sterigma is produced, from the apex of which a basidiospore is cut off by abstriction. The basidiospores are readily detached, and are carried by wind or other agency to leaves and shoots of plants growing in the vicinity. Should a basidiospore chance to alight on a young leaf or shoot of *Urtica* it germinates and produces a short hypha, which penetrates the cuticle and enters the host-tissues, where it rapidly branches and forms a subcuticular mycelium, which soon gives rise to small flask-shaped bodies, the spermogones.† The body of the spermogone is embedded in the host-tissues, the neck alone protruding; this is formed of numerous hair-like paraphyses (fig. 3) arranged in such a manner that a small circular or elliptical opening (ostiolum) is formed, through which the spermatia pass. The body is lined with hyphal

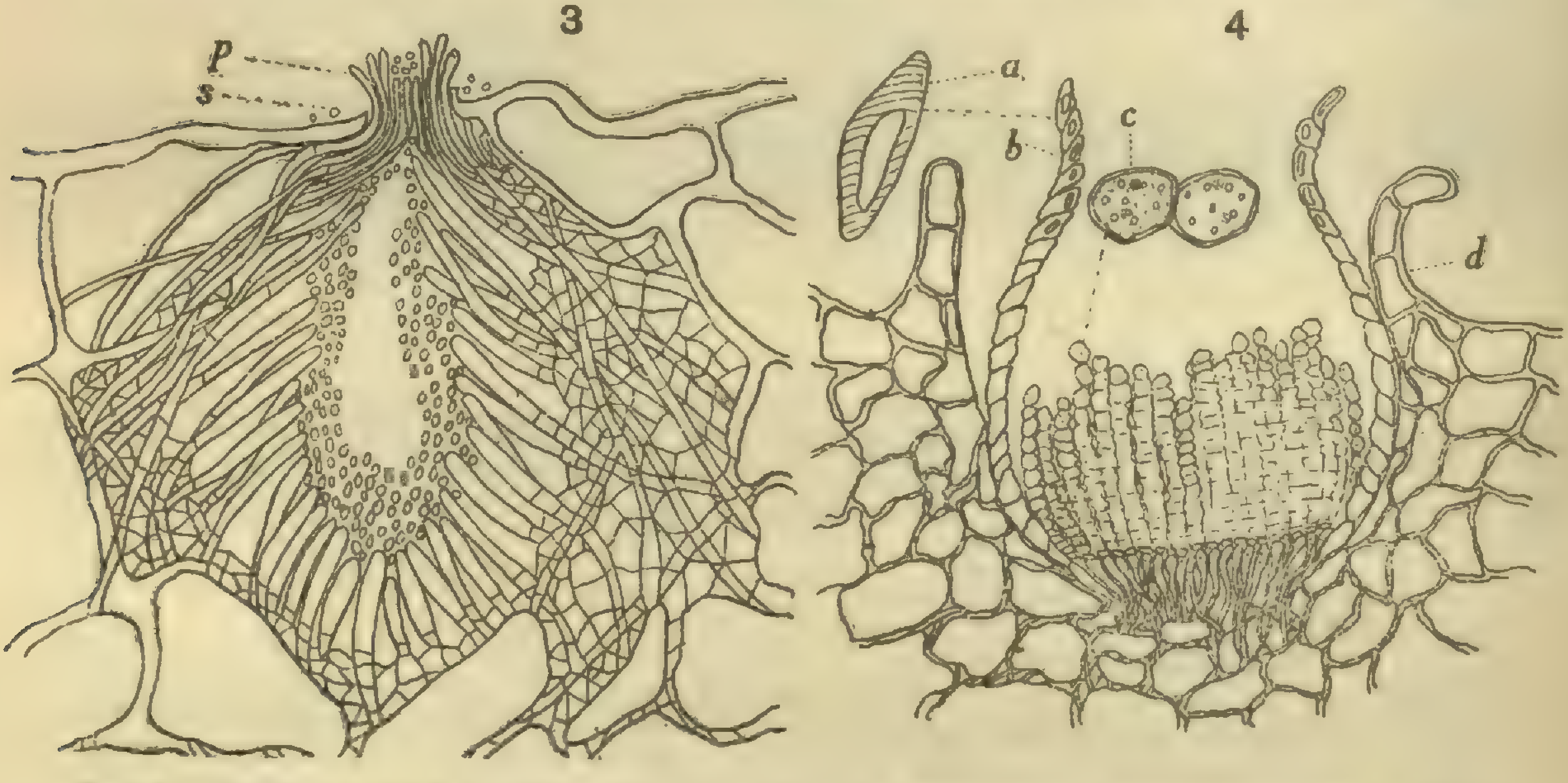

FIG. 3.—Spermogone of *Aecidium Ranuncularum*: *p*, paraphysis; *s*, spermatium. × 500.
FIG. 4.—Aecidium of *Puccinia tasmanica* Diet. from *Senecio lautus* Forst. f.: *a*, peridial cell; *b*, peridium; *c*, aecidiospore; *d*, host-tissues. × 250.

filaments, from the apices of which colourless elliptical spermatia are abstricted. The spermatia are embedded in a mucilaginous substance which is said to be somewhat sweet to the taste, and in certain species possesses a strong aromatic smell; doubtless these two features serve to attract insects, and so ensure dispersion of the spermatia. The mucilage is strongly hygroscopic, and in the presence of moisture swells and is forced through the ostiolum, carrying the spermatia with it on to the surface of the host, where it readily dissolves away and leaves the spermatia behind (see fig. 3, *s*).

As spermogones and spermatia are analogous to similar bodies found in the thallus of *Collema*, a genus of lichen, they were supposed to be male sexual organs, but as no corresponding female organ (trichogyne) has been

* This species is taken as a type because all spore stages are readily obtainable in New Zealand. This species was first suggested by W. B. Grove (1913) as a type in preference to *P. graminis*, as the aecidia are more easily obtained.

† Spermogones: Also known as "spermagonia," "pycnidia," or "pycnia."

observed in the Uredinales they were considerd to be functionless. Although they do not germinate when placed in water, Cornu showed that when placed in a weak sugar-solution the spermatia germinated readily, and produced a short hypha, which is but short-lived. The production of this hypha shows that, whatever the function of spermatia may be, it is not a sexual one; moreover, all experiments made with a view to ascertaining whether they will infect the host plant (and thus behave like conidia) have proved fruitless.

Shortly after the production of spermogones aecidia make their appearance. A typical aecidium consists of an outer peridium enclosing the central mass of aecidiospores (fig. 4). The peridium is at first globose and deeply immersed in the host-tissues, but owing to the gradually increasing pressure of the developing aecidiospores it becomes more or less cylindrical, until the apex reaches the surface, when it dehisces irregularly, the ruptured margins turning outwards until the peridium resembles a cup with widely-expanded margin. Sometimes dehiscence does not occur until the peridium extends some distance beyond the leaf-surface (Plate 77, fig. 1). The peridium is formed of irregularly hexagonal cells, whose inner surfaces are usually strongly sculptured (text-fig. 4, *a*). The peridium encloses the aecidiospores; these are produced in acropetal succession from basidia seated on the floor of the peridium; they are catenulate, and in young aecidia each spore is separated from its neighbour by a small compressed intercalary cell which soon disappears, so that its presence is often difficult to prove. The mature spores are at the top of the peridium, and as they are displaced others are forced into their place by the pressure of the developing spores below. Each spore is, as a rule, polygonal, owing to the pressure to which it has been subjected whilst within the peridium, and consists of an epispore, which is usually colourless, finely verruculose, and perforated by numerous obscure germ-pores, and granular contents brightly coloured by an oil which serves as reserve food. Generally aecidiospores remain viable but a short time, though cases have been recorded where they have germinated after a period of two months. In many species the mycelium is perennial and produces aecidia season after season; the presence of a perennial mycelium is usually indicated by distortion and yellowing of the host plant (Plate 77, fig. 2). Aecidiospores may give rise to further generations of aecidia on the same host, or may produce the next spore-stage in the cycle.

Should an aecidiospore alight on the leaf of *Carex*, if conditions are favourable it germinates and produces a single germ-tube (rarely more), which grows out through one of the germ-pores. As the germ-tube develops, the spore-contents pass into it and take up a position in its extremity. The germ-tube grows over the leaf-surface until it comes to a stoma, through which it passes, and in the stomal cavity swells, forming a vesicle which acts as a holdfast; once inside the stomal cavity it branches repeatedly, the branches (hyphae) penetrating between the cells of the host. From each hypha small haustoria are given off; these penetrate into the mesophyll cells and absorb the food substances necessary for their continued existence. The hyphae continue to develop rapidly until hyphal masses (mycelium) are formed immediately beneath the epidermis of the host. From this mycelium vertical hyphae are given off, on the apices of which small rounded cells are formed; these cells divide into two, the upper cell forming the uredospore, the lower the pedicel on which the uredospore is borne. By the pressure of these developing spores the epidermis becomes forced

upwards until a small blister is formed; this soon ruptures and exposes the uredospores. The mass of uredospores and their pedicels, together with the accompanying paraphyses (when present) collectively form the uredosorus. Mature sori are invariably surrounded and partially covered by the ruptured epidermis (Plate 77, fig. 3). Each uredospore is, as a rule, elliptical or subglobose, and consists of a coloured, echinulate epispore (text-fig. 5, A, *c*), perforated with one or several germ-pores, and containing the colourless, granular, and oily cell-contents. In certain species a thicker-walled spore, capable of remaining viable for a much longer period, is produced; this is termed an amphispore. Uredospores may remain viable but a short time, or may be capable of germination after a period of several months. Doubtless many of the rusts introduced into New Zealand are perpetuated by these spores alone, as their aecidia are absent, and their teleutospores are, in consequence, presumably functionless. From the same uredosori successive generations of uredospores are produced throughout the season. Uredospores are lightly attached to their pedicels, and, being readily detached, are carried by wind to other plants in the vicinity, and, if the hosts are suitable, give rise to uredosori. It is by this stage that many of the rusts are so widely distributed in a single season. Later in the season, in response to some stimulus, the teleutospore, or final spore in the cycle, is produced. Teleutospores may arise in sori produced directly from uredospore infection, or may be produced in the sori which have during the earlier part of the season produced uredospores. Teleutosori are, as a rule, similar in appearance to uredosori, but may generally be distinguished by their darker colour. In the sori teleutospores are formed in a similar manner to uredospores, save that the upper cell, after the first division (during which the pedicel is formed), again divides, and thus the two-celled spore is formed. The teleutospore consists of a thick-walled, usually smooth, dark-coloured epispore which is covered externally by a thin chitinous cuticle, and contains granular colourless cell-contents (fig. 5, B). In each cell a single germ-pore is present, which in the upper cell is usually apical, and in the basal usually immediately below the septum. Frequently in the teleutosori a second kind of teleutospore occurs; this is similar to the normal spore save that it is unicellular (fig. 2). They are called mesospores, and are probably teleutospores in which the second cell-division has, during their development, been omitted; they germinate in a similar manner to the normal spores, thus showing that they are functional. In the species under discussion the teleutospores are capable of remaining viable for many years; as a rule, however, they germinate the following spring, and from each germ-pore produce a basidium on which the basidiospores are borne. These, if they alight on *Urtica*, give rise to spermogones and aecidia, and so the cycle recommences.

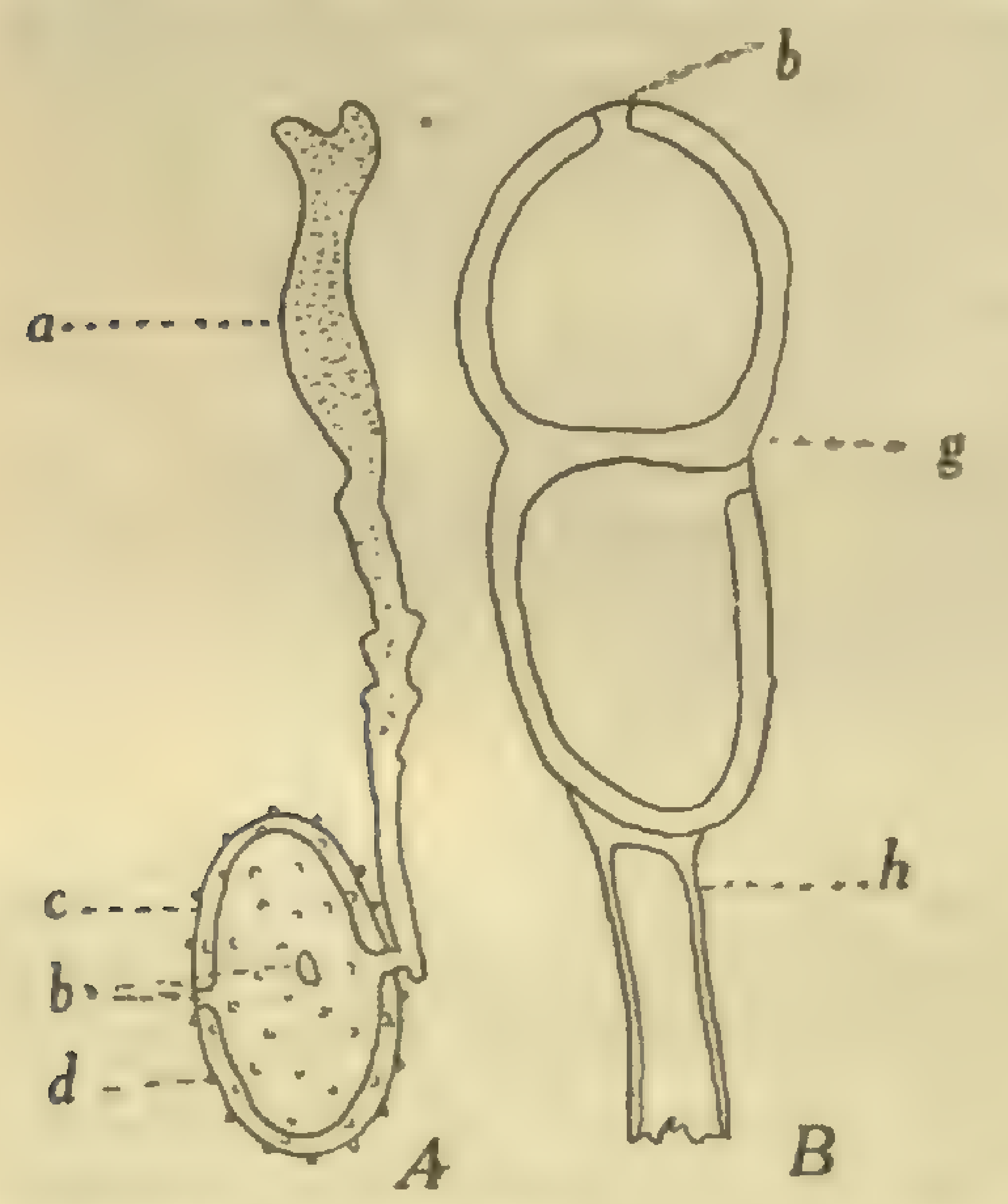

Fig. 5.—A. Germinating uredospore from *Anisotome aromatica* Hook. f.: *a*, germ-tube; *b*, germ-pores; *c*, epispore; *d*, sculpturing. × 500. B. Teleutospore of *Puccinia novae-zelandiae* n. sp.: *b*, germ-pore; *g*, septum; *h*, pedicel. × 325.

Variations from the above-described cycle occur in the different families and genera; these are more conveniently discussed under the generic descriptions, the above serving merely to convey some idea as to the different spore-forms commonly met with, and their relationships one with the other. For variations in the full cycle see the discussion under the genus *Puccinia.*

CYTOLOGY.

Space forbids more than brief mention of this subject here; fuller information may be obtained from the papers of Blackman (1904), Christman (1905, 1907), Olive (1908), &c.

Prior to the formation of aecidia, or primary uredosori (if the aecidia are absent), the hyphae beneath the epidermis first cut off a sterile cell from their apices; this undergoes no further development. The hyphal cell below this increases in size; it is at first uninucleate, but shortly becomes binucleate by the passage of a nucleus into it from an adjoining hyphal cell. The two nuclei do not fuse, but remain in the fusion cell, and, when this divides, both nuclei divide mitotically, but remain distinct from one another. This binucleate condition persists until teleutospore-formation, so that both aecidiospores and urediospores are binucleate. When a teleutospore is first formed both cells (*Puccinia*) are binucleate, but when the spore is nearly mature the nuclei fuse and each cell of the spore is then uninucleate. Consequently, when the teleutospore germinates, the resultant basidiospores, the mycelium to which they give rise, and the spermogones and their spermatia are all uninucleate.

DISTRIBUTION.

Of the 75 species discussed in this part, 46 are indigenous and the remainder are introduced. Of the 46 indigenous species, 23 are endemic, 19 occur in Australia, 15 in Tasmania, 4 in South America, and 6 extend to North America and Europe. The distribution may be illustrated better by the following table:—

Uromyces	
Microtidis ..	Aus.
puccinioides	Aus., Tas.
Thelymitrae	Aus.
Puccinia	
aucta ..	Aus.
Caricis ..	Aus., Tas., N.Am., Eur.
Cinerariae ..	Aus.
Coprosmae ..	Aus., Tas.
Dichondrae	Aus., Tas., N. S. Am.
distincta ..	Aus., Tas.
Erechtitis ..	Aus., Tas.
Hederaceae	Aus., Tas.
Hydrocotyles	N.Am., Eur., S.Am.
Puccinia	
juncophila ..	Aus., Tas.
Lagenophorae	Aus., Tas.
Menthae ..	Aus., Eur., N.Am.
Morrisoni ..	Aus., Tas.
obscura ..	N.Am., Eur.
Plagianthi ..	Tas.
pulverulenta	Aus., Tas., N.Am., Eur., S.Am.
tasmanica ..	Aus., Tas.
Tetragoni ..	Aus., Tas.
Thuemeni ..	Aus., Tas.
Unciniarum	Chile.

In this paper (tribe Puccineae) 26 families are recorded as being attacked:—

Aizoaceae	1 P.	Goodeniaceae	1 U.	Polygonaceae	1 U., 2 P.
Campanulaceae	1 P.	Gramineae	2 U., 6 P.	Ranunculaceae	2 P.
Chenopodiaceae	1 U.	Halorrhagaceae	1 P.	Rhamnaceae	1 U.
Compositae	19 P.	Juncaceae	2 P.	Rosaceae	1 P., 1 G.
Convolvulaceae	1 P.	Labiatae	1 P.	Rubiaceae	1 P.
Cruciferae	2 P.	Leguminosae	5 U., 4 Ur.	Scrophulariaceae	1 P.
Cyperaceae	2 P.	Malvaceae	3 P.	Umbelliferae	5 P.
Gentianaceae	2 P.	Onagraceae	1 P.	Violaceae	1 P.
Geraniaceae	2 P.	Orchidaceae	2 U.		

(G. = *Gymnoconia.* P. = *Puccinia.* U. = *Uromyces.* Ur. = *Uromycladium.*)

I wish to record my thanks to Mr. W. D. Reid, who has contributed the major number of the specimens in my herbarium; to Mr. E. H. Atkinson (Biological Laboratory), who has contributed large numbers of specimens, and who has undertaken the difficult task of verifying all host plants; to Messrs. H. H. Allan, A. H. Cockayne (Government Biologist), R. Waters, and many others for contributions of specimens; to Mrs. F. W. Patterson (Mycological Exchange Bureau, Washington), Dr. J. R. Weir (Director of the Forest Pathology Bureau, Washington), Mr. L. Rodway (Government Botanist, Hobart), and Mr. C. C. Brittlebank (Plant Pathologist, Melbourne) for material for comparative purposes; to Dr. W. B. Grove (University of Birmingham) for determination of species; Dr. E. J. Butler (Director, Imperial Bureau of Mycology) for looking up literature, and verifying references and authorities; Dr. L. Cockayne, F.R.S., for verifying authorities of many of the host plants; to Mr. J. G. Myers, B.Sc., for writing Latin diagnoses of all new species; and to Mr. E. Bruce Levy for the preparation of all the photographs used in this work.

I have found the following books particularly useful: *British Rust Fungi* (W. B. Grove); *North American Flora* (*Uredinales*), vol. 7; (J. C. Arthur); *Rusts of Australia* (D. McAlpine); *Sylloge Fungorum* (P. A. Saccardo); and *Thesaurus* (Lindau and Sydow).

All drawings were made with a camera lucida from spores mounted in a 50-per-cent. solution of lactic acid in water. Surface sculpturings have been studied from material mounted dry. Drawings are all to the same scale (unless otherwise specified), and have all been reduced the same amount; they were originally magnified 1,000 diameters. All descriptions are original and are drawn up from material in the herbarium of the author.

CLASSIFICATION.

Only those families and genera that occur in New Zealand are considered here.

Uredinales.

Microscopic fungi which are obligate parasites on ferns and higher plants. Mycelium branched, filamentous, septate, developing within the host-tissues, intercellular, sending haustoria into the host-cells; producing teleutospores which are borne in sori below the surface, or rarely singly within the host-tissues. Sori naked, enclosed by peridia or paraphyses, or embedded in a thin stroma. Teleutospores on germination producing a short, four-celled basidium, on which basidiospores are borne.

The order may be divided into the three following families:—

A. Germination by the formation of an internal basidium of four superimposed cells:
  Teleutospores in one or (rarely) two layers, forming waxy, bright-coloured crusts; one-celled, spores seated on dilated hyphal cells; aecidia with definite peridia; uredospores catenulate, or borne singly, not enclosed in peridia .. .. II. COLEOSPORIACEAE.

B. Germination by the formation of an external basidium:
  a. Teleutospores not pedicellate, seated on dilated hyphal cells; compacted laterally into flat crusts, or more rarely produced singly within the host-tissues; one-celled, or divided longitudinally into 2–4 cells; epispore coloured or hyaline; uredosori and aecidia with or without peridia; uredospores borne singly on definite pedicels .. .. I. MELAMPSORACEAE.
  b. Teleutospores pedicellate; borne singly on distinct pedicels, massed in pulvinate sori; one- or more-celled; epispore coloured or hyaline; aecidia with or without peridia; uredospores solitary on definite pedicels, without peridia .. .. .. III. PUCCINIACEAE.

In Part I the family Pucciniaceae, tribe Puccineae, is dealt with.

KEY TO GENERA OF THE PUCCINIACEAE.

a. Wall of teleutospore pedicel not or scarcely gelatinous ..	Tribe PUCCINEAE.
(*a.*) Teleutospores one-celled; with one germ-pore in a cell:	
Pedicel unbranched at or near the apex, spore solitary on pedicel	1. *Uromyces.*
Pedicel branched near apex, bearing one or more spores, with or without hyaline vesicle	2. *Uromycladium.*
(*b.*) Teleutospores two-celled; with one germ-pore in each cell:	
Aecidia with peridia	3. *Puccinia.*
Aecidia without peridia	4. *Gymnoconia.*
b. Wall of pedicel subgelatinous	Tribe PHRAGMIDEAE.
Teleutospores two- or more-celled by cross-septa; with one or more germ-pores in each cell.	
Teleutospores in pulvinate, dark-coloured sori ..	5. *Phragmidium.*
Teleutospores in yellow fibrils	6. *Hamaspora.*

Tribe PUCCINEAE.

1. UROMYCES Link.

Ges. Nat. Freunde Berlin Mag., vol. 7, p. 28, 1816.

Nigredo Rouss., *Fl. Calvados*, ed. 2, p. 47, 1806. *Caeomurus* S. F. Gray, *Nat. Arr. Brit. Pl.*, vol. 1, p. 541, 1821. *Pucciniola* Marchand, *Bijdr. Nat. Wet.*, vol. 4, p. 47, 1829. *Pileolaria* Cast., *Obs. Myc.*, vol. 1, p. 22, 1842. *Capitularia* Rab., *Bot. Zeit.*, vol. 9, p. 449, 1851. *Puccinella* Fcl., *Symb. Myc.*, p. 60, 1869. *Uromycopsis* Arth., *Result Sci. Congr. Bot. Vienne*, p. 345, 1906. *Klebahnia* Arth., *l.c.* *Spirechina* Arth., *Jour. Myc.*, vol. 13, p. 30, 1907. *Discospora* Arth., *N. Am. Fl.*, vol. 7, p. 149, 1907. *Teleutospora* Arth. & Bisby: Arth., *Bull. Torr. Cl.*, vol. 48, p. 38, 1921. *Haplotelium* Syd., *Ann. Myc.*, vol. 20, p. 124, 1922.

Autoecious or heteroecious. Cycle of development includes 0, I, II, III.

0. Spermogones flask-shaped, immersed, the surrounding paraphyses alone protruding, honey-coloured.

I. Aecidia at first immersed, becoming erumpent and cupulate, or cylindrical. Peridia hyaline, less frequently coloured, margins erect or revolute, dentate, lacerate, or seldom entire. Aecidiospores catenulate, commonly polygonal, less frequently elliptical; epispore usually verruculose, hyaline, seldom tinted, with numerous scattered and indistinct germ-pores.

II. Uredosori without peridia, commonly pulverulent, with or without paraphyses, and usually surrounded by the ruptured epidermis. Uredospores from globose to obovate, borne singly at the apices of pedicels; epispore commonly echinulate, less frequently verrucose, coloured, with one or several evident germ-pores which may be scattered or equatorially arranged.

III. Teleutosori compacted, less frequently pulverulent, naked or long covered. Teleutospores unicellular, borne singly on distinct pedicels; epispore smooth or variously sculptured, usually coloured, with one distinct apical germ-pore.

New Zealand species 13, of which 5 are indigenous, 2 being endemic, and the remainder introduced.

This genus is closely related to the genus *Puccinia* (*q.v.*), and is separated solely on account of the difference in the number of cells in the teleutospore.

In this paper the different species are arranged under their host families, the classification of Engler and Prantl in their *Natuerlichen Pflanzenfamilien* being followed. Where several species occur on different hosts belonging to the same family, they are arranged under that family in alphabetical order.

1. Uromyces Dactylidis Otth. (Fig. 6.) Gramineae (1).

Otth., *Mittheil. Nat. Gesell. Bern.*, p. 85, 1861.

**Aecidium Ranunculi-acris* Pers., *Obs. Myc.*, vol. 2, p. 22, 1795. *Aecidium Ranunculacearum* DC., *Fl. Fr.*, vol. 6, p. 97, 1815, *p.p. Uromyces graminum* Cke., *Handbk.*, p. 520, 1871.

0. Spermogones epiphyllous, honey-coloured.

I. Aecidia hypophyllous, and on petioles, seated on yellow spots, orange. Peridia cupulate, margins recurved, somewhat lacerate, white. Spores polygonal, 17–25 mmm.† diam.; epispore pale yellow, delicately verruculose.

II. Uredosori amphigenous, chiefly epiphyllous, scattered, or arranged in lines, up to 2 mm. long, pale brown, pulverulent, surrounded by the ruptured epidermis. Spores subglobose to obovate, 23–32 × 20–25 mmm.; epispore delicately and sparsely echinulate, 1·5–2 mmm. thick, golden-brown, cell-contents sulphur-yellow, with 3–5 scattered, usually papillate germ-pores on one face.

III. Teleutosori amphigenous, chiefly hypophyllous, scattered, or arranged in lines, up to 2 mm. long, black, compact, bullate, long covered. Spores obovate, often pyriform, rarely elliptical, 20–27 × 15–19 mmm.; apex bluntly rounded, seldom acuminate, sometimes truncate, slightly (4 mmm.) or not thickened, darker in colour, base attenuate; epispore smooth, 1–1·5 mmm. thick, pale golden-brown, cell-contents vacuolate, nucleus prominent; pedicel persistent, tinted, up to 30 × 5 mmm.; germ-pore apical, obscure; paraphyses numerous, agglutinated into masses dividing the sori into compartments, chestnut-brown.

Host: *Dactylis glomerata* L. On leaves, sheaths, and culms. Herb. No. 288. II, III. Turakina; Kelburn (Wellington), *G. H. C.* Jan., 1921. II, III. Ettrick (Otago), *A. H. Cockayne!* 10 Feb., 1921. III. Tauranga (Auckland), *G. H. C.* 15 May, 1921.

Distribution: Europe.

The aecidia, which occur on *Ranunculus* spp., have not been collected in New Zealand. Opinions are divided as to the presence or absence of paraphyses in the teleutosori. In the New Zealand material they are abundant, and divide the sori into small compartments. They are somewhat swollen at their apices and tend to overarch the teleutospores, probably functioning as protective organs.

This species closely resembles *U. Poae* Rab., and by several authors is considered to be identical; others, again, separate them on both morphological (Grove, 1913, p. 128) and biological (Juel, 1908) grounds.

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* As most of the literature in which the earlier synonymy is published is not available in New Zealand, I have compiled the synonyms in this work from the publications of J. C. Arthur, F. Bubak, W. B. Grove, D. McAlpine, and P. A. Saccardo. Wherever necessary, dates and publications cited have been verified by reference to *Thesaurus* of Lindau and Sydow.

† In this article the contraction "mmm." is used for micromillimetres.

2. Uromyces otakou n. sp.* (Fig. 7.)

0, I. Unknown.

II. Uredosori epiphyllous, scattered, rarely linear, elliptical, up to 2 mm. long, bright orange-yellow, pulverulent, surrounded by the ruptured epidermis. Spores globose or subglobose, 20–30 mmm. diam.; epispore densely and minutely verrucose, 1–1·5 mmm. thick, hyaline, cell-contents orange, with 5–8 scattered germ-pores on one face.

III. Teleutosori epiphyllous, scattered, seldom confluent and forming lines, dark chestnut-brown, up to 3 mm. long, pulvinate, compact, surrounded by the ruptured epidermis. Spores obovate, 24–30 × 19–23 mmm; apex round, seldom bluntly acuminate, thickened up to 12 mmm., base subattenuate, frequently rounded; epispore smooth, 2–2·5 mmm. thick, chestnut-brown; pedicel persistent, tinted, up to 60 × 8 mmm; germ-pore apical, obscure.

Host: *Poa caespitosa* Spreng. On leaves and sheaths. Herb. No. 363. II, III. Routeburn Valley (Otago), 800 m., *W. D. Reid!* 6 May, 1921. (Type.) II. Cashmere Hills (Canterbury), 400 m., *W. D. Reid!* 31 July, 1921. Mount Judah (Otago), 800 m., *W. D. Reid!* 13 Dec., 1921.

The host is an indigenous species; it occurs also in Australia and Tasmania (Cheeseman, 1906, p. 907). The teleutospores are rare and difficult to find; they occur, as a rule, near the base of the sheath. The uredosori are plentiful, but in dried material difficult to find, owing to the fact that they are epiphyllous and are covered by the halves of the leaves folding together when drying. This species differs from *U. Dactylidis* in the greatly thickened apex of the teleutospore, different shape, and stouter pedicel. The uredospores closely resemble those of *Puccinia Poarum* Niels., but may be separated by the somewhat thicker and verrucose epispore; in *P. Poarum* the epispore is densely and sharply echinulate.

3. Uromyces Microtidis Cooke. (Fig. 8.) Orchidaceae (2).

Cke., *Grev.*, vol. 14, p. 12, 1885.

0. Spermogones amphigenous, associated with the aecidia, scattered, minute, erumpent, honey-coloured.

I. Aecidia amphigenous, scattered, minute, 100–150 mmm. diam., pale orange. Peridia cupulate, margins white, slightly expanded but not revolute, dentate. Spores polygonal, 15–20 × 12–16 mmm.; epispore hyaline, 1 mmm. thick, delicately and minutely verruculose, cell-contents orange, vacuolate.

II. Uredosori similar to and indistinguishable from the teleutosori. Spores elliptical to obovate, 20–30 × 17–23 mmm.; epispore sparsely and coarsely verruculose, tinted brown, 1–1·5 mmm. thick, with three equatorial germ-pores on one face.

III. Teleutosori amphigenous, chiefly hypophyllous, elliptical, scattered, or aggregated into irregular groups, rarely confluent, bullate, up to 2 mm. long, pulverulent, long covered, finally becoming exposed by the epidermis rupturing longitudinally. Spores subglobose, elliptical, or frequently obovate, 25–35 × 20–26 mmm.; apex acuminate, often with a hyaline apiculus, thickened up to 8 mmm., base attenuate, frequently rounded; epispore coarsely warted or knobbed, 2·5–3 mmm. thick, chestnut-brown,

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* Latin diagnoses of new species are arranged in alphabetical order in an appendix at the end of Part I.

cell-contents granular; pedicel decidous, hyaline, up to 50 × 10 mmm.; germ-pore apical, conspicuous.

Host: *Microtis porrifolia* R. Br. On leaves and sheaths. Herb. No. 331.
II, III. Tiritea, Palmerston North (Wellington), *G. H. C.* 3 Mar., 1921.
I, II, III. Hills near Petone (Wellington), *E. H. Atkinson!* 20 Dec., 1921.

Distribution: Australia.

The host is indigenous; it occurs also in Australia. The aecidia have not been recorded previously; they closely resemble those of *Uromyces Thelymitrae.* The latter species is distinguished by the larger, less warted, and less acuminate teleutospore.

4. Uromyces Thelymitrae McAlpine. (Fig. 9.)

McAlp., *Rusts Aus.*, p. 90, 1906.

0. Spermogones amphigenous, associated with the aecidia, scattered, minute, erumpent, honey-coloured.

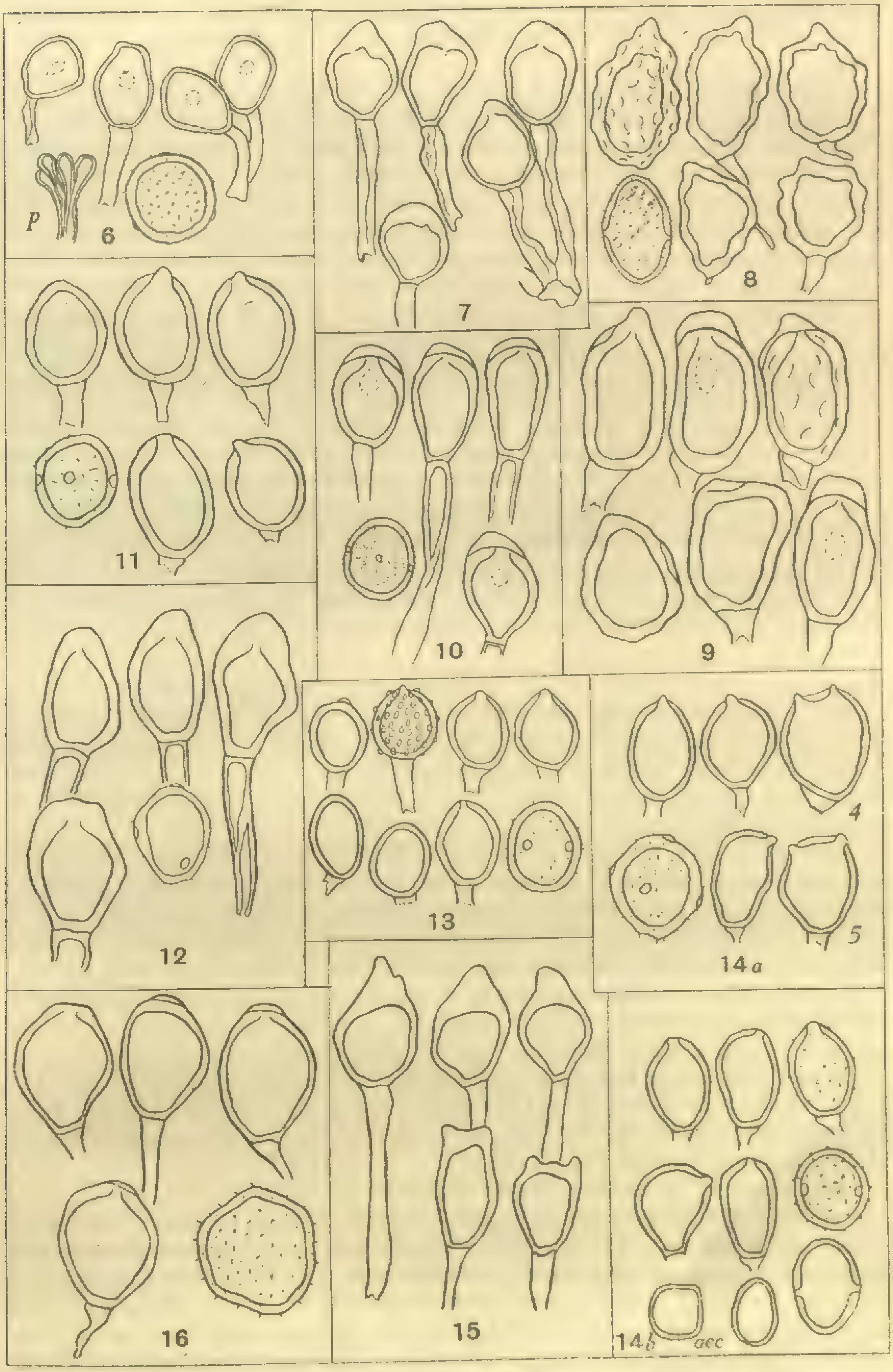
I. Aecidia amphigenous, scattered, minute, 100 – 120 mmm. diam., orange. Peridia cupulate, margins pallid yellow, revolute, dentate. Spores polygonal, 17–22 mmm. diam.; epispore 1 mmm. thick, finely and densely verruculose, cell-contents orange-yellow.

II. Uredosori amphigenous, elliptical, scattered, or aggregated into irregular groups, seldom confluent, up to 2 mm. long, bullate, chocolate-brown, pulverulent, becoming exposed by the epidermis rupturing longitudinally. Spores subglobose, elliptical, or obovate, 25–30 × 16–21 mmm.; epispore 2 mmm. thick, closely and delicately echinulate, pallid yellow, cell-contents bright yellow, 3–4 equatorial germ-pores on one face.

III. Teleutosori amphigenous, chiefly hypophyllous, scattered, or aggregated, seldom confluent, chocolate-brown, bullate, pulverulent, long covered, finally becoming exposed by the epidermis rupturing longitudinally. Spores elliptical, obovate, often polygonal, very irregular, 35–55 × 20–35 mmm.; apex bluntly acuminate, thickened up to 7 mmm., usually with a conspicuous hyaline apiculus, base attenuate; epispore 3–4 mmm. thick, irregularly knobbed or angled, chestnut-brown, cell-contents coarsely granular; pedicel decidous, hyaline, up to 60 × 12 mmm.; germ-pore apical, conspicuous.

Fig. 6.—*Uromyces Dactylidis* Otth. Uredo- and teleuto-spores from *Dactylis glomerata* L. *p* = paraphyses.
Fig. 7.—*Uromyces otakou* sp. nov. Teleutospores from *Poa caespitosa* Spreng.
Fig. 8.—*Uromyces Microtidis* Cke. Uredo- and teleuto-spores from *Microtis porrifolia* R. Br.
Fig. 9.—*Uromyces Thelymitrae* McAlp. Teleutospores from *Thelymitra longifolia* Forst. f.
Fig. 10.—*Uromyces Polygoni* Fcl. Uredo- and teleuto-spores from *Polygonum aviculare* L.
Fig. 11.—*Uromyces Betae* Lev. Uredo- and teleuto-spores from *Beta vulgaris* L.
Fig. 12.—*Uromyces Fabae* de Bary. Uredo- and teleuto-spores from *Vicia Faba* L.
Fig. 13.—*Uromyces striatus* Schroet. Uredo- and teleuto-spores from *Medicago sativa* L.
Fig. 14*a*.—*Uromyces Trifolii* Lev. Uredo- and teleuto-spores from *Trifolium pratense* L. Nos. 4 and 5 have two germ-pores.
Fig. 14*b*.—*Uromyces Trifolii-repentis* Liro. Aecidio-, uredo-, and teleuto-spores from *Trifolium hybridum* L. Aec. = aecidiospores.
Fig. 15.—*Uromyces Discariae* sp. nov. Teleutospores from *Discaria toumatou* Raoul.
Fig. 16.—*Uromyces puccinioides* Berk. et F. v. M. Uredo- and teleuto-spores from *Selliera radicans* Cav.

Camera-lucida drawings by author. All × 500.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Host: *Thelymitra longifolia* Forst. f. On leaves and sheaths. Herb. No. 319. I, II, III. Upper Hutt (Wellington), *Miss J. M. Anson!* 27th Nov., 1921. II, III. York Bay (Wellington), *E. H. Atkinson!* 13th Feb., 1921.

Distribution: Australia.

The host is indigenous and widespread; it occurs also in Australia and Tasmania (Cheeseman, 1906, p. 670). The aecidia, hitherto unrecorded, are abundant on the specimens forwarded by Miss Anson; they are remarkable for their minute size, and for the irregular manner in which they are scattered over the leaf. This rust differs from *U. Microtidis* in the larger and more coarsely knobbed teleutospores.

5. **Uromyces Polygoni** Fuckel. (Fig. 10.) Polygonaceae (3).

Fcl., *Symb. Myc.*, p. 64, 1869.

Puccinia Polygoni Pers., *Neues. Mag. Bot.*, vol. 1, p. 119, 1794. *P. Polygonii-Aviculare* Pers., *Syn. Fung.*, p. 227, 1801. *P. Aviculare* DC., *Fl. Fr.*, vol. 2, p. 221, 1805. *Dicaeoma Aviculare* S. F. Gray, *Nat. Arr. Brit. Pl.*, vol. 1, p. 542, 1821. *Uromyces Aviculare* Schroet., *Abh. Schles. Ges.*, vol. 68, p. 8, 1870. *Puccinia vaginalium* Link.: Cke., in *Handbk.*, p. 495, 1871. *Aecidium Aviculare* Kuntze: Cke., *l.c.*, p. 545. *Caeomurus Polygoni* Kuntze, *Rev. Gen.*, vol. 3, p. 450, 1898. *Nigredo Polygoni* (Pers.) Arth., *Res. Sci. Congr. Bot. Vienne*, p. 344, 1906.

0. Spermogones amphigenous, scattered, honey-coloured.

I. Aecidia amphigenous, chiefly hypophyllous, crowded on irregular discoloured spots. Peridia cupulate, margins hyaline, erect, dentate. Spores polygonal, frequently globose, 15–18 mmm. diam.; epispore densely and finely verruculose, 1 mmm. thick, hyaline, cell-contents pale yellow.

II. Uredosori amphigenous and caulicolous, scattered, circular, pulverulent, up to 1 mm. diam., surrounded by the ruptured epidermis. Spores broadly elliptical, obovate, or subglobose, 25–30 × 18–22 mmm.; epispore finely and densely verruculose, 1·5–2 mmm thick, golden-brown, with 4 equatorial germ-pores on one face.

III. Teleutosori amphigenous, more frequently caulicolous, on leaves scattered, on stems forming lines up to 10 mm. long, compact, pulvinate, chocolate-brown, soon naked. Spores elliptical, frequently obovate, sometimes pyriform, 25–40 × 16–25 mmm.; apex rounded, often bluntly acuminate, sometimes truncate, thickened up to 8 mmm., darker in colour, base attenuate; epispore smooth, 2–2·5 mmm. thick, cinnamon-brown, cell-contents granular; pedicel persistent, hyaline, or frequently tinted, up to 120 × 12 mmm.; germ-pore apical, conspicuous.

Host: *Polygonum aviculare* L. On leaves and stems. Herb. Nos. 8, 317. I, II, III. Lincoln (Canterbury), *T. Kirk!* 16th Nov., 1881. II, III. Tauranga (Auckland), *G. H. C.* 13th Jan., 1920. II, III. Alexandra (Otago), *A. H. Cockayne!* 10th Feb., 1921.

Distribution: Australia; North America; Europe; Africa; Asia.

Arthur (1917, p. 296) has by cultural experiments shown that the teleutospores of *Puccinia subnitens* Diet., when sown on *Polygonum aviculare*, produce spermogones and aecidia on that host, and claims in consequence that the aecidia "hitherto erroneously associated with *U. Polygoni*" are of *P. subnitens* and not of *U. Polygoni*. In America this may be so, but in New Zealand all three stages have been collected at the same time on the same host plant; and, moreover, as *P. subnitens* has not been collected in New Zealand, it would appear that Arthur's supposition is not applicable here.

6. **Uromyces Betae** Leveille. (Text-fig. 11, and Plate 77, fig. 3.)
Chenopodiaceae (4).

Lev., *Ann. Sci. Nat.*, ser. 3, vol. 8, p. 375, 1847.

Uredo Betae Pers., *Syn. Fung.*, p. 220, 1801. *Caeoma Betarum* Link., in Willd. *Sp. Pl.*, vol. 6, p. 11, 1825. *Trichobasis Betae* Lev. : Cke. in *Micro. Fungi.*, p. 209, 1865. *Aecidium Betae* Kuhn., *Zeitschr. Landv. Central-Ver. Suchs.*, vol. 26, p. 41, 1869. *Caeomurus Betae* Kuntze, *Rev. Gen.*, vol. 3, p. 449, 1898. *Nigredo Betae* (Pers.) Arth., *Res. Sci. Congr. Bot. Vienne*, p. 343, 1906.

0. Spermogones amphigenous, in small groups, honey-coloured.

I. Aecidia amphigenous, crowded in irregular groups, on yellowish spots. Peridia cupulate, margins hyaline, reflexed, dentate. Spores globose to polygonal, 16–26 × 17 22 mmm.; epispore densely and finely verruculose, hyaline, 1·5–2 mmm. thick, cell-contents pale yellow.

II. Uredosori amphigenous, scattered, circular, up to 2 mm. diam., cinnamon-brown, pulverulent, surrounded by the ruptured epidermis. Spores elliptical, frequently subglobose, 20–35 × 18–25 mmm.; epispore sparsely and finely echinulate, 2·5–3 mmm. thick, golden-brown, with 2–3 equatorial germ-pores on one face.

III. Teleutosori similar to uredosori but chestnut-brown. Spores broadly elliptical, frequently obovate, 24–35 × 18–25 mmm.; apex rounded, not or slightly (4 mmm.) thickened, base rounded; epispore smooth, 2·5–3 mmm. thick, golden-brown, cell-contents vacuolate; pedicel deciduous, hyaline, up to 30 × 8 mmm.; germ-pore apical, conspicuous, crowned with a prominent hyaline papilla.

Host: *Beta vulgaris* L. On leaves. Herb. Nos. 30, 32. II. Lincoln (Canterbury), *T. Kirk!* Nov., 1881. II, III. Weraroa (Wellington), *G. H. C.* May, Sept., 1919.

Distribution: Australia; South Africa; North America; Europe.

This species is common on cultivated red-beet, sugar-beet, and mangolds. The aecidia have not been collected in New Zealand, so that in all probability the rust is perpetuated by uredospores alone; these may be found the year around.

7. **Uromyces Fabae** de Bary. (Fig. 12.) Leguminosae (5).

De Bary, *Ann. Sci. Nat.*, ser. 4, vol. 20, p. 80, 1863.

Uredo Fabae Pers., in *Roem. Neues. Mag. Bot.*, vol. 1, p. 93, 1794. *U. Viciae-Fabae* Pers., *Syn. Fung.*, p. 221, 1801. *U. Viciae* Rebent., *Prodr. Fl. Neom.*, p. 355, 1804. *Caeoma leguminosarum* Schlecht., *Fl. Berol.*, vol. 2, p. 127, 1824. *Uromyces appendiculatus* Ung., *Einfl. Bodens.*, p. 216, 1836. *U. Viciae* Fcl., *Symb. Myc.*, p. 62, 1869. *Aecidium album* G. W. Clinton: Peck, *Ann. Rep. N.Y. State Mus.*, vol. 31, p. 43, 1879. *Uromyces polymorphus* Peck and Clinton: Peck, *l.c.* *Nigredo Fabae* (Pers.) Arth., *N. Am. Fl.*, vol. 7, p. 251, 1912.

0. Spermogones amphigenous, sparse, honey-coloured.

I. Aecidia hypophyllous, solitary or aggregated in small groups, seated on pale-yellow spots. Peridia cupulate, margins hyaline, revolute, finely lacerate. Spores elliptical, or polygonal, 18–25 × 16–20 mmm.; epispore densely verruculose, hyaline, 1–1·5 mmm. thick.

II. Uredosori amphigenous, scattered, circular, up to 1·5 mmm. diam., cinnamon-brown, pulverulent, surrounded by the ruptured epidermis. Spores globose, or elliptical, frequently obovate, 25–32 × 18–25 mmm.; epispore sparsely and finely echinulate, 1·5–2 mmm. thick, golden-brown, with 3–4 scattered germ-pores on one face.

III. Teleutosori amphigenous and caulicolous, on leaves similar to uredosori but chocolate-brown, on stems and petioles scattered and elliptical, or more commonly confluent and forming areas reaching a length of 25 mm. or more, compact, pulvinate, chocolate-brown, soon naked. Spores elliptical, frequently obovate, 30–45 × 18–25 mmm.; apex bluntly acuminate, or as frequently rounded, sometimes truncate, thickened up to 12 mmm., darker in colour, base attenuate; epispore smooth, 2–2·5 mmm. thick, dark chestnut-brown, cell-contents vacuolate; pedicel persistent, tinted, up to 120 × 10 mmm.; germ-pore apical, conspicuous.

Host: *Vicia Faba* L. On leaves, petioles, stems, and legumes. Herb. No. 31. II, III. Palmerston North (Wellington), *G. H. C.* April, June, 1919.

Distribution: Australia; North America; Europe; Asia; Ceylon.

The aecidia have not been collected in New Zealand. The teleutosori form conspicuous black masses on the petioles and stems. The rust is prevalent in New Zealand wherever the host is grown. It is distinguished by the thick apex and smooth epispore of the teleutospore.

8. **Uromyces flectens** Lagerheim.

Lagerh., *Svensk. Bot. Tidsskrift.*, vol. 3, p. 36, 1909.

Puccinia neurophila De Toni, *Sacc. Syll.*, vol. 7, p. 698, 1888.

0. Spermogones unknown.

III. Teleutosori amphigenous, and on petioles and veins, on inflated and distorted areas, scattered when elliptical and 1 mm. long or more, commonly confluent when up to 3 mm. long, bullate, pulverulent, chocolate-brown, long covered by the epidermis. Spores elliptical, subglobose, obovate, 18–27 × 15–22 mmm.; apex rounded, not thickened, base rounded; epispore finely warted, warts arranged in irregular striae, or less commonly smooth, 1·5 mmm. thick, chestnut-brown; pedicel deciduous, hyaline, subturbinate, short, 30 × 6 mmm.; germ-pore apical, conspicuous, papillate.

Hosts:—

Trifolium repens L. On leaves, petioles, and veins. Herb. No. 490. III. Cluny, Turakina (Wellington), *Mrs. M. Cunningham!* 3rd Jan., 1922.

Trifolium fragiferum L. On leaves and petioles. III. Kelburn (on plants imported from Australia), *E. Bruce Levy!* 9th Mar., 1922.

Distribution: Europe; Asia.

This species has been separated from *U. Trifolii-repentis* Liro because of the fact that only teleutosori occur in the cycle, and because of the larger sori, which are longer covered, and are more common on nerves and petioles.

9. **Uromyces striatus** Schroeter. (Fig. 13.)

Schroet., *Abhandl. Schles. Ges.*, p. 11, 1872.

Uredo apiculata var. *Trifolii* Strauss., *Ann. Wett.*, vol. 2, p. 97, 1810, *p.p.*

0. Spermogones hypophyllous, numerous, honey-coloured.

I. Aecidia hypophyllous, scattered. Peridia cupulate, margins white, revolute, lacerate. Spores polygonal, 18–23 mmm. diam.; epispore densely verruculose, hyaline, 1·5 mmm. thick, cell-contents orange.

II. Uredosori amphigenous, scattered, elliptical, up to 1·5 mm. long, pulverulent, cinnamon-brown, surrounded by the ruptured epidermis.

Spores subglobose to elliptical, 20–25 × 15–20 mmm.; epispore sparsely and finely echinulate, 2 mmm. thick, pallid brown, with 3–5 scattered, papillate germ-pores on one face.

III. Teleutosori similar to and intermixed with the uredosori, chestnut-brown. Spores obovate or subglobose, 18–25 × 15–18 mmm.; apex rounded, not or scarcely thickened, base usually rounded, seldom attenuate; epispore 2 mmm. thick, covered with warts, which are arranged in irregular longitudinal striae, cinnamon-brown; pedicel deciduous, hyaline, up to 30 × 8 mmm.; germ-pore apical, conspicuous, crowned with a narrow hyaline papilla.

Host: *Medicago sativa* L. On leaves and stems. Herb. No. 362. II, III. Blenheim (Marlborough), *J. G. Myers!* 13th Mar., 1921.

Distribution: Europe; North and South America (?).

The aecidia, which occur on *Euphorbia* spp., have not been collected in New Zealand. It is probable that *U. Medicaginis* Pass. is a synonym of this species, as from the description they appear to be identical. I have compared specimens of *U. striatus* on this host from America (kindly supplied by Mrs. F. W. Patterson) with the New Zealand material and find them to be identical. Distinguished by the strongly warted epispore.

10. Uromyces Trifolii Leveille. (Fig. 14*a*.)

Lev., *Ann. Sci. Nat.*, ser. 3, vol. 8, p. 371, 1847.

Puccinia Trifolii Hedw. f.: DC. in *Fl. Fr.*, vol. 2, p. 225, 1805. *Uredo fallens* Desmaz., *Pl. Crypt.*, 1325, 1843. *Trichobasis fallens* Cke., *Jour. Bot.*, vol. 4, p. 105, 1866. *Puccinia fallens* Cke., *Handbk.*, p. 508, 1871, *p.p.* *Uromyces fallens* Kern., *Phytopathology*, vol. 1, p. 6, 1911. *Nigredo fallens* (Desmaz.) Arth., *N. Am. Fl.*, vol. 7, p. 254, 1912.

0, I. Unknown.

II. Uredosori amphigenous, scattered, circular, up to 1 mm. diam., cinnamon-brown, pulverulent, surrounded by the ruptured epidermis. Spores subglobose to broadly elliptical, 20–28 × 18–25 mmm.; epispore sparsely and finely echinulate, 2–2·5 mmm. thick, golden brown, with 3–6 scattered germ-pores on one face, sometimes papillate.

III. Teleutosori associated with and scarcely distinguishable from the uredosori, chestnut-brown. Spores broadly elliptical, obovate, or sometimes globose, 20–30 × 16–22 mmm.; apex rounded, not thickened, base attenuate, seldom rounded; epispore smooth, or with a few scattered warts, 1·5 mmm. thick, cinnamon-brown, cell-contents granular; pedicel deciduous, hyaline, short, frequently turbinate, up to 30 × 6 mmm.; germ-pore varying in position from apical to half-way down side, conspicuous, covered with a prominent hyaline papilla.

Hosts:—

Trifolium hybridum L. On leaves and stems. Herb. No. 321. II, III. Ettrick (Otago), *A. H. Cockayne!* 10 Feb., 1921.

Trifolium incarnatum L. On leaves. Herb. No. 321. II. Ruakura (Auckland), *G. H. C.* 28 Feb., 1921.

Trifolium pratense L. On leaves, petioles, and stems. Herb. No. 29. II, III. Marton, *C. Schwass!* 15 Feb., 1921. Weraroa (Wellington), *G. H. C.* 5 May, 1919.

Trifolium subterraneum L. On leaves. Herb. No. 29. II. Weraroa (Wellington), *G. H. C.* 16 June, 1919.

Distribution: North America; Europe; Asia Minor; Persia.

In the sori one sometimes finds teleutospores with two distinct germ-pores (figs. 14*a*, 4, and 5). Liro (1906, p. 15) separated from *U. Trifolii* the form occurring on *Trifolium repens* because it would not infect *T. hybridum* and *T. pratense*, and gave to it the name of *U. Trifolii-repentis.* These two forms are maintained as distinct species by Sydow (1910, p. 131) because of the absence of aecidia and the presence of a larger number (3–6) of scattered germ-pores in *U. Trifolii.* A third form, *U. flectens*, on *T. repens*, was in 1909 separated by Lagerheim, as only teleutospores occur in the cycle, these appearing in sori which are larger, appear more frequently on the petioles and veins, and are longer covered by the epidermis.

11. Uromyces Trifolii-repentis Liro. (Fig. 14*b*.)

Liro, *Act. Soc. Faun. Flor. Fenn.*, vol. 29, p. 15, 1906.

Uromyces Trifolii Plow., *Ured.*, p. 124, 1889, *p.p.* *Trichobasis fallens* Cke., *Micr. Fung.*, p. 226, 1865, *p.p.* *Puccinia fallens* Cke., *Handbk.*, p. 508, 1871, *p.p.* *Nigredo Trifolii* Arth., *N. Am. Fl.*, vol. 7, p. 255, 1912.

0. Spermogones epiphyllous, in minute clusters, immersed, honey-coloured.

I. Aecidia hypophyllous and on petioles, in circular or elliptical groups, up to 5 mm. diam., crowded, pallid yellow. Peridia cupulate, margins expanded but not or scarcely revolute, white, laciniate. Spores polygonal, 18–25 × 15–17 mmm.; epispore finely and densely verruculose, 1 mmm. thick, hyaline, cell-contents pale orange.

II. Uredosori amphigenous, and on petioles, cinnamon-brown, scattered, or confluent and linear, circular, minute, up to 0·5 mm. diam., bullate, pulverulent, surrounded by the ruptured epidermis. Spores globose, elliptical, or obovate, 17–25 × 16–22 mmm.; epispore sparsely and somewhat coarsely echinulate, 1·5 mmm. thick, golden-brown, with 2–4 (usually 2) equatorial germ-pores on one face.

III. Teleutosori amphigenous, on leaves circular, minute, 0·5 mm. diam., on petioles linear, up to 5 mm. long, chocolate-brown, bullate, pulverulent, long covered. Spores globose, elliptical, or obovate, 18–28 × 15–22 mmm.; apex rounded, not or scarcely thickened, base rounded, epispore smooth or with a few scattered and minute warts, 1·5–2 mmm. thick, chestnut-brown; pedicel deciduous, hyaline, commonly subturbinate, short, up to 45 × 6 mmm.; germ-pore apical, or one-third way down side, conspicuous, covered with a prominent hyaline papilla.

Host: *Trifolium hybridum* L. On leaves and petioles. Herb. No. 501. I, II, III. Ruakura (Auckland), *A. W. Green!* 9 Jan., 1922.

Distribution: Australia; North and South America; Europe; Asia.

Distinguished by the presence of all three spore-stages, and by the smaller number of germ-pores in the uredospores.

12. Uromyces Discariae n. sp. (Text-fig. 15, and Plate 77, fig. 1.)

Rhamnaceae (6).

Aecidium Discariae Cke., *Grev.*, vol. 14, p. 89, 1886.

0. Spermogones hypophyllous, preceding the aecidia, in confluent groups, sometimes circinnate, minute, immersed, honey-coloured.

I. Aecidia hypophyllous, closely aggregated on yellow spots which are visible on the upper surface. Peridia tubular, standing above the leaf-surface 1 mm., bright orange, margins erect, hyaline, dentate.

Spores polygonal or globose, 26–32 × 22–26 mmm.; epispore hyaline, 1·5–2 mmm. thick, densely and minutely verruculose, cell-contents orange, vacuolate.

III. Teleutosori hypophyllous, scattered, seated on yellow spots, chocolate-brown, pulvinate, compact, circular or more commonly elliptical, up to 5 mm. long, long covered. Spores elliptical or subglobose, irregular, 23–33 × 15–21 mmm.; apex acuminate or bluntly rounded, thickened up to 10 mmm., base abruptly attenuate, seldom rounded; epispore smooth, 2 mmm. thick, chestnut-brown, cell-contents granular, nucleus evident; pedicel persistent, tinted, up to 80 × 5 mmm.; germ-pore apical, conspicuous.

Host: *Discaria toumatou* Raoul. On leaves. Herb. No. 43. I. Otekaike (Otago), *T. Kirk!* 1889. Loburn; Dunstan Mountains (Otago), 3–500 m., *W. D. Reid!* Dec., 1921. I, III. Paradise (Otago), 500 m., *W. D. Reid!* 11 Dec., 1921. (Type.) III. Queenstown Domain; Cardrona Valley; Ben Lomond Track (Otago) *W. D. Reid!* Mar., April, 1921.

The host is endemic and widely distributed. The aecidia were in 1889 collected and sent to Kew by the late Mr. T. Kirk. Recently Mr. Reid has collected and forwarded abundant specimens of both stages.

13. Uromyces puccinioides Berkeley and F. von Mueller. (Fig. 16.)
Goodeniaceae (7).

Berk. et F. v. M., *Linn. Jour. Bot.*, vol. 13, p. 173, 1872.

0. Unknown.

I. Aecidia amphigenous, scattered, erumpent. Peridia cupulate, margins hyaline, erect, dentate. Spores elliptical, frequently polygonal, 20–25 × 12–18 mmm.; epispore hyaline, finely and densely verruculose, 1 mmm. thick, cell-contents pale-yellow, granular.

II. Uredosori amphigenous, scattered, irregular, frequently elliptical, up to 3 mm. long, bullate, pulverulent, cinnamon-brown, finally becoming exposed by the epidermis fissuring longitudinally. Spores globose or subglobose, seldom elliptical, 25–35 mmm. diameter; epispore sparsely aculeate, 1·5–2 mmm. thick, pale brown, with 2 equatorial germ-pores on one face.

III Teleutosori mixed with and indistinguishable from the uredosori. Spores elliptical, obovate, often pyriform, 28–35 × 18–26 mmm.; apex bluntly rounded, thickened up to 5 mmm., base subattenuate; epispore smooth, 1·5–2 mmm. thick, pale chestnut-brown, cell-contents vacuolate; pedicel persistent, hyaline, up to 45 × 8 mmm.; germ-pore apical, conspicuous.

Host: *Selliera radicans* Cav. On leaves. Herb. Nos. 189, 326. I. Evans Bay (Wellington), *T. Kirk!* 1884. II, III. Mouth of Hutt River (Wellington), *E. H. Atkinson!* 2 Feb., 1921. I, II. Ashburton (Canterbury), *H. H. Allan!* 14th Jan., 1920. I. Dunstan Mountains (Otago), *A. H. Cockayne!* 6 Feb., 1921. I, II, III. Dunstan Mountains (Otago), *W. D. Reid!* Dec., 1921.

Distribution: Australia.

The host is indigenous and widespread; it occurs also in Australia (Cheeseman, 1906, p. 394). McAlpine's description (1906, p. 91) does not altogether agree with the above, differing chiefly in the absence of uredospores. Comparison with Australian material, however, shows the teleutospores to be very similar to one another.

2. Uromycladium McAlpine.

McAlp., *Ann. Myc.*, vol. 3, p. 303, 1905.

Autoecious. Cycle of development includes 0, II, III.

0. Spermogones subcuticular, aparaphysate, subglobose, preceding or accompanying uredosori or teleutosori, or both.

II. Uredosori without peridia, commonly pulverulent, aparaphysate, naked. Uredospores borne singly at the apices of hyaline pedicels, elliptical or fusoid; epispore warted or reticulated, with several (2–7) evident equatorial germ-pores.

III. Teleutosori commonly pulverulent, erumpent, naked. Teleutospores depressed globose, in clusters at or near the apex of a common pedicel (sporophore), clusters composed of one spore and a hyaline vesicle, or two or more spores with or without a vesicle; pedicel hyaline, septate; epispore smooth, warted, or striate, germ-pore apical, solitary, conspicuous.

New Zealand species 4, introduced.

This genus, with the exception of one species, is confined to Australasia, where it attacks but the one genus of host plant, *Acacia*. Two of the species form large galls on branches and pods; it is probable that the mycelium is perennial in these galls, as their surfaces become covered year after year with the ochraceous or cinnamon spore-masses. The genus is peculiar chiefly in the manner in which the teleutospores are borne on the pedicels. There may be a single teleutospore at the apex of the pedicel, with a hyaline vesicle immediately underneath; two spores without a vesicle; two spores and a vesicle; or three spores without a vesicle.

McAlpine records seven species for Australia.

1. Uromycladium Robinsoni McAlpine. (Figs. 17, 21*a*.)

Leguminosae (1).

McAlp., *Rusts Aus.*, p. 109, 1906.

0. Spermogones amphigenous, usually surrounded by the uredosori or teleutosori, in small groups, sparse, pallid brown.

II. Uredosori amphigenous, scattered, or more frequently crowded and forming circinnate groups up to 2 mm. diam., circular, or more often

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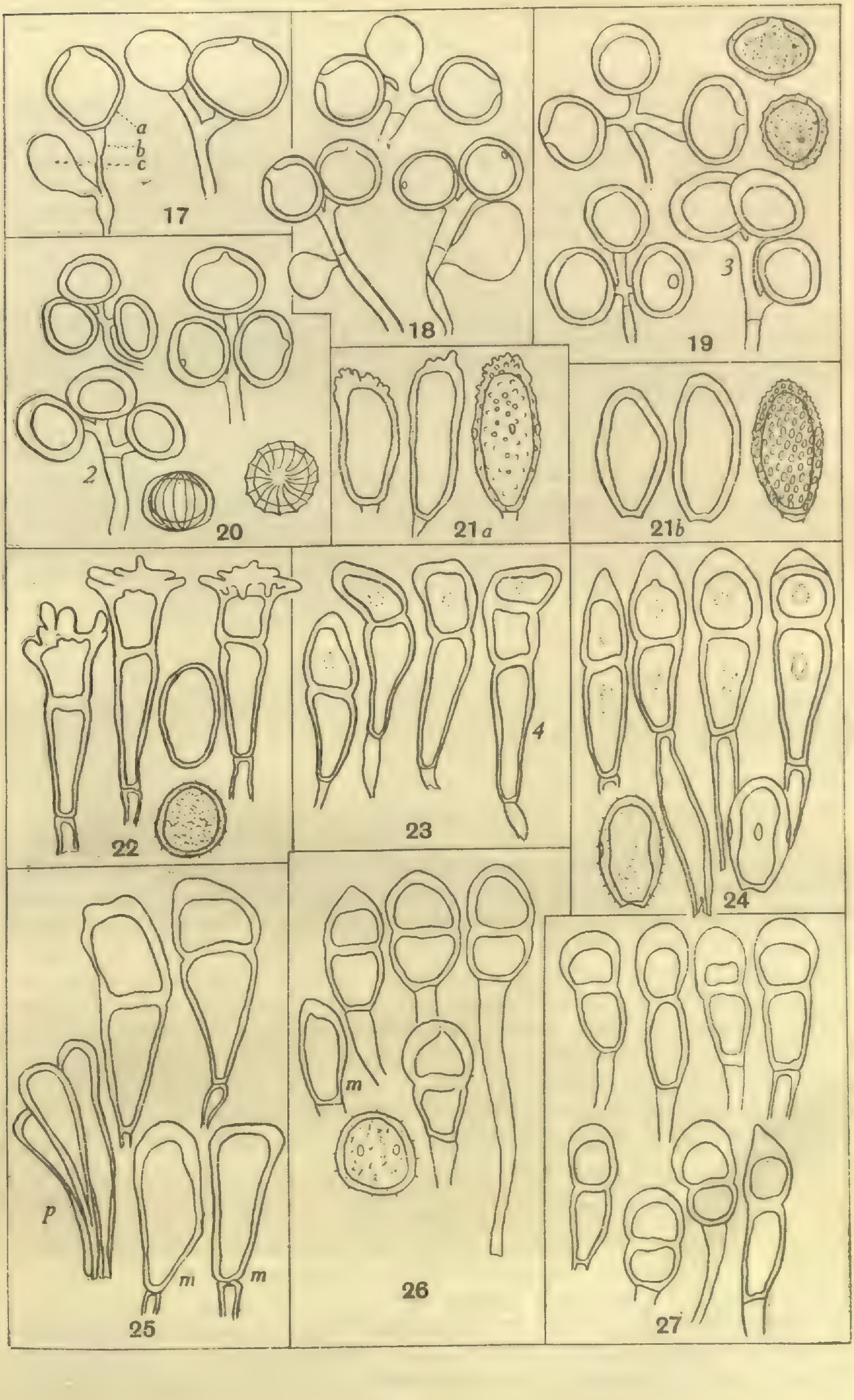
Fig. 17.—*Uromycladium Robinsoni* McAlp. Teleutospores from *Acacia melanoxylon* R. Br. *a*, teleutospore; *b*, pedicel; *c*, vesicle.
Fig. 18.—*Uromycladium alpinum* McAlp. Teleutospores from *Acacia dealbata* Link.
Fig. 19.—*Uromycladium notabile* McAlp. Teleutospores from *Acacia decurrens* Willd. No. 3 is immature; note thick walls.
Fig. 20.—*Uromycladium Tepperianum* (Sacc.) McAlp. Teleutospores from *Acacia armata* R. Br. No. 2 is immature.
Fig. 21*a*.—*Uromycladium Robinsoni* McAlp. Uredospores.
Fig. 21*b*.—*Uromycladium notabile* McAlp. Uredospores.
Fig. 22.—*Puccinia coronata* Cda. Uredo- and teleuto-spores from *Avena sativa* L.
Fig. 23.—*Puccinia dispersa* Erikss. et Henn. Teleutospores from *Secale cereale* L. No. 4 is a three-celled form.
Fig. 24.—*Puccinia graminis* Pers. Uredo- and teleuto-spores from *Triticum vulgare* Vill.
Fig. 25.—*Puccinia simplex* Erikss. et Henn. Teleuto- and meso-spores from *Hordeum vulgare* L.
Fig. 26.—*Puccinia Sorghi* Schw. Uredo- and teleuto-spores from *Zea Mais* L.
Fig. 27.—*Puccinia Caricis* Shroet. Teleutospores from *Carex ternaria* Forst. f.

Camera-lucida drawings by author. All × 500. *m* = mesospores. *p* = paraphyses.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elliptical, pale chestnut-brown, pulverulent. Spores elliptical, less commonly fusoid, 38–45 × 19–22 mmm.; epispore closely and coarsely warted, pale yellowish-brown, 2 mmm. thick, thickened at the apex to 6 mmm., with 2–3 equatorial germ-pores on one face.

III. Teleutosori similar to and mixed with the uredosori, dark chestnut-brown. Spores solitary at the end of the pedicel, with a globose lateral vesicle beneath, depressed globose to globose, 19–26 × 25–34 mmm.; apex slightly thickened, 3–4 mmm.; epispore smooth, pale chestnut-brown, 1·5–2 mmm. thick; pedicel persistent, hyaline, fragile; germ-pore apical, conspicuous; vesicle globose to obovate, 16–24 mmm. diam., hyaline, wall smooth, delicate, pedicel persistent, hyaline, attached laterally to pedicel of spore.

X. Mesospores common, elliptical, 18–22 × 9–12 mmm.; epispore smooth, 1 mmm. thick, pale chestnut-brown, germ-pore absent.

Host: *Acacia melanoxylon* R. Br. On phyllodes. Herb. No. 285. II, III. Te Kauwhata (Auckland), *L. Paynter!* 11 Jan., 1921.

Distribution: Australia; Tasmania.

This species is distinguished by the presence of a single teleutospore at the apex of the pedicel, and a single hyaline lateral vesicle immediately beneath, and by the uredospore being coarsely warted, and thickened at the apex.

2. **Uromycladium alpinum** McAlpine. (Fig. 18.)

McAlp., *Rusts Aus.*, p. 105, 1906.

0. Spermogones amphigenous, crowded, seated on discoloured spots, associated with uredo- and teleuto-sori, black, minute.

II. Uredosori amphigenous, scattered, or in groups, elliptical, up to 3 mm. diam., cinnamon-brown, bullate, soon naked. Spores elliptical, or clavate, 35–51 × 21–26 mmm.; epispore covered with warts, which are densely and evenly arranged, golden-brown, not or slightly thickened at the apex, 2 mmm. thick, with 3–5 equatorial germ-pores on one face.

III. Teleutosori amphigenous, in irregularly elliptical pulvinate groups, up to 10 mm. in length, compact, chocolate-brown, bullate, soon naked. Teleutospores two at apex of pedicel, each attached by a short lateral pedicel, with a hyaline lateral vesicle immediately beneath, depressed globose to globose, 19–22 × 25–30 mmm.; apex slightly (3–3·5 mmm.) thickened; epispore smooth, 1·5–2 mmm. thick, yellowish to chestnut-brown; germ-pore apical, conspicuous; pedicel hyaline, persistent, up to 120 × 6 mmm.; vesicle arising from pedicel immediately below septum, attached by a short hyaline lateral pedicel, obovate to globose, up to 25 mmm. diam., wall smooth, hyaline.

X. Mesospores common, elliptical to obovate, 15–25 × 10–15 mmm.; apex not thickened, germ-pore absent.

Hosts:—

Acacia dealbata Link. On leaves. Herb. No. 431. Tauranga (Auckland), *G. H. C.* 17 Jan., 1920.

Acacia decurrens Willd. On leaves and branches. Pukekino, Hastings (Hawke's Bay), *F. B. Logan!* 3 Jan., 1921.

Distribution: Australia; Tasmania.

This species may readily be recognized by the two apical teleutospores attached to the common pedicel. The teleutospores are smooth, and possess a thin epispore. The uredospores are usually clavate, and are evenly warted all over.

3. Uromycladium notabile McAlpine. (Figs. 19, 21*b*.)

McAlp., *Rusts Aus.*, p. 108, 1906.

Uredo notabilis Ludw., *Bot. Centrbl.*, vol. 43, p. 6, 1890.

0. Spermogones associated with the uredo- and teleuto-sori, amphigenous and caulicolous, minute, black.

II. Uredosori on branches and pods, seated on distorted inflated galls, ochraceous, pulverulent, covering entire surfaces, naked. Spores elliptical or commonly fusoid, 30–45 × 18–28 mmm.; epispore strongly reticulated, 3 mmm. thick, yellowish-brown, apex not or slightly thickened, with 3–5 equatorial germ-pores on one face.

III. Teleutosori on branches and pods, seated on distorted inflated galls, chocolate-brown, pulverulent, naked. Spores in clusters of three attached to the apex of a common pedicel by short lateral pedicels, vesicle absent, depressed globose, often somewhat angular, 16–23 × 21–26 mmm.; apex thickened, up to 4 mmm.; epispore densely covered with fine warts, which are arranged in lines converging at the poles, pale chestnut-brown, 1·5–2 mmm. thick; pedicel hyaline, deciduous, up to 45 × 5 mmm.; germ-pore apical, conspicuous.

Hosts:—

Acacia dealbata Link. On branches and pods. Herb. Nos. 271, 355. II, III. Tauranga (Auckland), *G. H. C.* 17 Jan., 1920.

Acacia decurrens Willd. On branches. II. Pukekino, Hastings, *F. B. Logan!* 3 Jan., 1920.

Distribution: Australia; Tasmania.

Readily recognized by the gall-forming habit. The uredospores are ochraceous in mass, and the epispore is strongly reticulated, thus distinguishing it from any other species. The teleutospores are readily separable from their pedicels, and it is thus difficult to make out the grouping. Nevertheless, as the epispore is covered with fine striae, formed of fine warts arranged in lines, the species is readily determinable.

4. Uromycladium Tepperianum (Saccardo) McAlpine. (Fig. 20.)

McAlp., *Rusts Aus.*, p. 111, 1906.

Uromyces Tepperianus Sacc., *Hedw.*, vol. 28, p. 126, 1889.

0. Spermogones amphigenous, associated with the teleutosori, scattered, minute, chocolate-brown.

III. Teleutosori on branches, seated on distorted inflated galls, cinnamon-brown, pulverulent, naked. Spores in clusters of three, attached by a short lateral pedicel to the common pedicel, vesicle absent, depressed globose or subglobose, 14–17 × 18–25 mmm.; apex slightly (3 mmm.) thickened; epispore strongly striate, striae continuous and converging at the poles, 1–1·5 mmm. thick, cinnamon-brown; pedicel deciduous, hyaline, up to 80 × 5 mmm.; germ-pore apical, conspicuous.

Host: *Acacia armata* R. Br. On branches. Herb. No. 354. III. Auckland, *D. Miller!* 15 Feb., 1921.

Distribution: Australia; Tasmania.

The teleutospores occur in groups of three near the apex of the common pedicel; owing to their deciduous nature, this grouping is difficult to make out in mature sori, but may readily be seen in immature specimens. The species is, however, readily determined by the striate epispore of the teleutospore. This species forms large galls on the branches of the host. McAlpine records finding a gall weighing 3 lb. No uredospores are known.

3. Puccinia Persoon.

Pers., *Tent. Disp. Meth.*, p. 38, 1794.

Bullaria DC., *Fl. Fr.*, vol. 2, p. 226, 1805. *Dicaeoma* S. F. Gray, *Nat. Arr. Brit. Pl.*, vol. 1, p. 541, 1821. *Solenodonta* Cast., *Cat. Pl. Mars.*, p. 202, 1845. *Eriosporangium* Bertero: Lev., *Ann. Sci. Nat.*, ser. 3, vol. 5, p. 269, 1846. *Trichobasis* Lev., *Orb. Dict. Hist. Nat.*, vol. 12, p. 785, 1848. *Ceratitium* Rab., *Bot. Zeits.*, vol. 9, p. 451, 1851. *Cutomyces* Thuem., *Jor. Sci. Lisboa*, vol. 6, p. 239, 1878. *Rostrupia* Lagerh., *Jour. de Bot.*, vol. 3, p. 188, 1889. *Jackya* Bubak, *Oesterr. Bot. Zeits.*, vol. 52, p. 42, 1902. *Micropuccinia* Rostr., *Plantep. Haandb.*, p. 266, 1902. *Leptopuccinia* Rostr., *l.c.*, p. 268. *Tranzschelia* Arth., *Result Sci. Congr. Bot. Vienne*, p. 340, 1906. *Polythelis* Arth., *l.c.*, p. 341. *Allodus* Arth., *l.c.*, p. 345. *Dasyspora* Arth., *l.c.*, p. 346. *Polioma* Arth., *Jour. Myc.*, vol. 13, p. 29, 1907. *Nephlyctis* Arth., *l.c.*, p. 31. *Prospodium* Arth., *l.c.* *Argomyces* Arth., *N. Am. Fl.*, vol. 7, p. 217, 1912. *Sclerotelium* Sydow, *Ann. Myc.*, vol. 19, p. 172, 1921. *Coronotelium* Syd., *l.c.* *Peristemma* Syd., *l.c.*, p. 175. *Schroeterella* Syd., *ibid.*, vol. 20, p. 119, 1922. *Trailia* Syd., *l.c.*, p. 121.

Autoecious or heteroecious. Cycle of development includes 0, I, II, III.

0. Spermogones flask-shaped, immersed, the surrounding paraphyses alone protruding, honey-coloured.

I. Aecidia at first immersed, becoming erumpent and cupulate or cylindrical. Peridia hyaline, less frequently coloured, margins erect or revolute, dentate, lacerate, or seldom entire. Aecidiospores catenulate, commonly polygonal, less commonly elliptical; epispore usually verruculose, hyaline, seldom tinted, with numerous scattered and indistinct germ-pores.

II. Uredosori without peridia, commonly pulverulent, with or without paraphyses, and usually surrounded by the ruptured epidermis. Uredospores globose to obovate, borne singly at the apices of pedicels; epispore commonly echinulate, less frequently verrucose, coloured, with one or several evident germ-pores, which may be scattered over the surface or equatorially arranged.

III. Teleutosori compacted, less frequently pulverulent, naked or long covered by the epidermis. Teleutospores bicellular, borne singly on the apices of distinct pedicels; epispore smooth or variously sculptured, coloured or less commonly hyaline, with one distinct germ-pore in each cell, germ-pore varying in position from apex to base of each cell.

New Zealand species 57, of which 41 are indigenous, 21 being endemic.

This species is closely related to the genus *Uromyces*, being separated solely on account of the two-celled teleutospores.

Although in the introduction the full cycle was discussed, it does not follow that all species have a cycle including all spore-stages. For example, we have species with all stages present, or with one or more omitted, as under (0 = spermogones; I = aecidia; II = uredospores; III = teleutospores):—

0, I, II, III = Eu-form: *e.g.*, *Puccinia clavata* Syd.
0, I, III = Opsis-form: *e.g.*, *Puccinia distincta* McAlp.
0, II, III = Brachy-form: *e.g.*, *Puccinia obtegens* Tul.
0, III = Micro-form: *e.g.*, *Puccinia Plagianthi* McAlp.

As a rule, when spermogones accompany a stage it is an indication that that is the first stage to appear, and thus is some indication as to the length of the cycle; for example, if spermogones accompany the uredosori (primary) the aecidia are generally absent, and if spermogones accompany teleutosori, then both aecidia and uredospores are absent. Where the rust is heteroecious, with its aecidia on one host and uredo- and teleuto-sori on another, there is, as a rule, nothing to indicate the relationship between the two forms,

save the proximity of the two stages and their hosts. In such an instance cultural experiments are the only means of determining the relationships. Species are arranged under their host-families, the hosts being arranged according to the classification of Engler and Prantl. This treatment serves in some measure to split the genus (which now contains over 1,500 species) into groups, and brings all closely related species together. That this is necessary is evident when one considers the number that have been erected on host-distinctions alone.

1. **Puccinia coronata** Corda. (Fig. 22.) Gramineae (1).

Cda., *Icon. Fung.*, vol. 1, p. 6, 1837.

Aecidium Rhamni Pers., in J. F. Gmel. *Syst. Nat.*, vol. 2, 1472, 1791. *A. crassum* Pers., *Neues. Mag. Bot.*, vol. 1, p. 92, 1794. *A. Cathartici* Schum., *Enum. Pl. Saell.*, vol. 2, p. 225, 1803. *A. Allenii* G. W. Clinton: Peck, in *Ann. Rep. N. Y. State Mus.*, vol. 24, p. 93, 1872. *A. pulcherrimum* Rav.: Berk., in *Grev.*, vol. 3, p. 1874. *Puccinia Lolii* Niels., *Ugeskr. Landw.*, vol. 4, p. 549, 1875. *P. Rhamni* Wettst., *Vehr. Zool-Bot. Ges. Wien*, vol. 35, p. 545, 1886. *P. coronifera* Kleb., *Zeits. Pflanzenkr.*, vol. 4, p. 135, 1894. *P. Catharticae* Lagerh., *Tromosoe Mus. Aarsh.*, vol. 17, p. 52, 1895. *P. Melicae* Syd., *Mon. Ured.*, vol. 1, p. 760, 1902. *Dicaeoma Melicae* Arth., *Proc. Ind. Acad. Sci.*, 1903, p. 149, 1904. *Puccinia Beckmanniae* McAlp., *Rusts Aus.*, p. 116, 1906. *P. praegracilis* Arth., *Bull. Torr. Club*, vol. 34, p. 585, 1907. *P. Erikssonii* Bubak, *Arch. Nat. Land. Boehem.*, vol. 13, p. 107, 1908. *Dicaeoma Rhamni* (Pers.) Kuntze, *Rev. Gen.*, vol. 7, p. 470, 1898.

0. Spermogones amphigenous, associated with the aecidia, reddish-brown.

I. Aecidia amphigenous, compacted in small groups on yellow distorted spots, and on flowers and fruits, orange-yellow. Peridia cylindrical, margins hyaline, revolute, finely laciniate. Spores globose or broadly elliptical, 16–24 × 14–20 mmm.; epispore hyaline, closely and finely verruculose, 1–1·5 mmm. thick.

II. Uredosori amphigenous, and on sheaths, at first scattered and elliptical, becoming aggregated and often linear, frequently reaching a length of 2–3 mm., bullate, brownish-yellow, becoming pulverulent and naked. Uredospores globose, elliptical, or obovate, 22–30 × 18–25 mmm.; epispore finely and rather sparsely echinulate, 1–1·5 mmm. thick, pale yellow, with 3–4 scattered germ-pores on one face; a few hyaline capitate paraphyses sometimes present.

III. Teleutosori amphigenous, scattered, when 0·5 mm. long, or confluent and linear, frequently reaching a length of 2–3 mm., black, bullate, compact, long covered. Teleutospores elongate-clavate, often cuneiform, 40–60 × 11–20 mmm.; apex truncate, darker in colour, thickened, up to 7 mmm., and crowned with a variable number (5–8) of curved, digitate processes, variable in shape and size, frequently reaching a length of 10 mmm., base attenuate, basal cell longer, narrower, and much lighter in colour than the upper; not or slightly constricted at the septum; epispore smooth, yellowish-brown, 1–1·5 mmm. thick, cell-contents vacuolate; pedicel persistent, coloured, short, thick, continuous with the spore, up to 20 × 9 mmm.; germ-pore of upper cell apical, obscure, basal pore midway between septum and pedicel, obscure.

Hosts:—

Avena sativa L. On leaves and sheaths. Herb. Nos. 232, 301, 327. II, III. Waikanae (Wellington), *R. Waters!* 24 Nov., 1920. Ruakura (Auckland), *G. H. C.* 28 Feb., 1921.

Holcus lanatus L. On leaves, sheaths, and stems. Herb. Nos. 273, 318. II, III. Turakina; Weraroa; Kelburn (Wellington), *G. H. C.* Nov.–Jan., 1920–21. II, III. Ettrick (Otago), *A. H. Cockayne!* 10 Feb., 1921. II, III. Hooper's Inlet (Otago), *R. B. Tennent!* 21 Feb., 1921.

Lolium multiflorum Lam. Ruakura (Auckland), *A. W. Green!* 9 Jan., 1922.

Lolium perenne L. On leaves. Herb. No. 327. II. Ruakura (Auckland), *G. H. C.* 28 Feb., 1921. Kelburn (Wellington), *G. H. C.* Dec., 1921.

Distribution: World-wide.

The aecidial stage does not occur in New Zealand, so that in all probability the rust is perpetuated by the uredo stage alone. Viable uredospores are to be found on *Holcus lanatus* the year around.

Puccinia coronata was the name first applied by Corda to a species characterized by the coronate apex of the teleutospore. Nielsen (1875, p. 549) showed that when aecidiospores from *Rhamnus cathartica* were sown on leaves of *Lolium perenne* uredospores were produced, whereas aecidiospores from *Rhamnus Frangula* failed to infect this host. He therefore proposed to separate this latter form from *P. coronata* and to name it *P. Lolii.*

Klebahn (1894, p. 258) carried out similar experiments with the teleutospores from *Lolium perenne*, sowing them on *Rhamnus cathartica*, the result being the production of aecidia, whereas he failed to produce aecidia on *R. Frangula.* He therefore split *P. coronata* into two species, retaining the original name for the form with its aecidial stage on *Rhamnus Frangula*, and to the form with its aecidial stage on *P. cathartica* he proposed to give the name of *P. coronifera*, overlooking the fact that this form had previously been named by Nielsen.

Eriksson (1894, p. 292) showed by cultural experiments that *P. coronata* and *P. Lolii* each consisted of five biological races, as under:—

a. *Puccinia coronata* Cda. Aecidial stage on *Rhamnus Frangula.*
   1. f. *Calamagrostis*—on *Calamagrostis lanceolata* and *Phalaris.*
   2. f. *Phalaridis*—on *Phalaris arundinacea* and *Calamagrostis.*
   3. f. *Agrostis*—on *Agrostis stolonifera, A. alba,* and *A. vulgaris.*
   4. f. *Agropyri*—on *Agropyron repens.*
   5. f. *Holci*—on *Holcus lanatus* and *H. mollis.*

b. *Puccinia Lolii* Niels. Aecidial stage on *Ramnus cathartica.*
   1. f. *Avenae*—on *Avena sativa* and *A. fatua.*
   2. f. *Lolii*—on *Lolium perenne.*
   3. f. *Festucae*—on *Festuca elatior* and *F. gigantea.*
      (Klebahn showed that uredospores from *Festuca* would infect *Holcus lanatus, H. mollis,* and *Lolium perenne.*)
   4. f. *Alopecuri*—on *Alopecurus pratensis,* &c.
   5. f. *Glyceriae*—on *Glyceria aquatica.*

Klebahn added to this list

   6. f. *Holci,*

as he showed that uredospores from *Holcus lanatus* would infect only *Holcus lanatus* and *H. mollis.*

After further cultural work Eriksson (1908) revised his previous work and separated *P. Lolii* into eight biological races. Other workers have obtained entirely different results: for example, Carleton (1899), who claims that in North America there is only one host of *P. Lolii* in nature.

As there are few or no morphological differences between these two forms (the aecidial stages not occurring here), I have thought it advisable to include them under the original name, as Arthur and Fromme (1920, p. 313) have done; in this work they give a list of 40 hosts, embracing 21 genera.

2. **Puccinia dispersa** Eriksson and Henning. (Fig. 23.)

Erikss. et Henn., *Zeitschr. f. Plf.-Krankh.*, vol. 4, p. 141, 1894.

Aecidium Asperifolii Pers., *Obs. Myc.*, vol. 1, p. 97, 1796. *A. Lycopsidis* Desv., *Jour. de Bot. Desv.*, vol. 2, p. 311, 1809. *Uredo rubigo-vera* DC., *Fl. Fr.*, vol. 6, p. 83, 1815. *Puccinia recondita* Roberge: Desmaz., *Bull. Soc. Bot. Fr.*, vol. 4, p. 798, 1858. *P. straminis* Fcl., *Enum. Fung.*, vol. 9, p. 2, 1861. *P. rubigo-vera* Wint., in Rab., *Krypt. Fl.*, vol. 1, p. 217, 1881. *P. Asperifolii* Wettst., *Vehr. Zool.-Bot. Ges. Wien*, vol. 35, p. 541, 1886. *Aecidium Anchusae* Erikss. et Henn., *Getreider.*, p. 210, 1896. *Puccinia dispersa* (*sens. strict.*) Erikss., *Ann. Sci. Nat.*, ser. 8, vol. 9, p. 268, 1899. *P. Bromina* Erikss., *l.c.*, p. 271. *P. Holcina* Erikss., *l.c.*, p. 274. *Dicaeoma Asperifolii* (Pers.) Kuntze, *Rev. Gen.*, vol. 3, p. 466, 1898. *Puccinia Symphyti-Bromorum* F. Muell., *Beihefte. Bot. Centralb.*, vol. 10, p. 201, 1901. *P. Secalina* Grove, *Brit. Rust Fungi*, p. 261, 1913.

0. Spermogones amphigenous, scattered, or in compact groups, honey-coloured.

I. Aecidia amphigenous, and on calices, seated on spots which may reach a diam. of 2 mm., yellow. Peridia low, fairly broad, margins revolute, finely laciniate. Aecidiospores polygonal, subglobose, or elliptical, 20–31 × 15–22 mmm.; epispore closely and finely verruculose.

II. Uredosori amphigenous, light ferruginous-brown, elliptical or linear, 0·5–2 mm. long, rarely confluent, pulvinate, becoming pulverulent, surrounded by ruptured epidermis. Spores subglobose or elliptical, 22–30 × 22–25 mmm.; epispore finely and closely echinulate, 1·5–2 mmm. thick, yellowish-brown, with 4–6 scattered germ-pores on one face.

III. Teleutsori amphigenous, chiefly hypophyllous, black, elliptical, or more frequently linear, when up to 3 mm. long, long covered, divided into compartments and entirely surrounded by dark-brown, slightly clavate, stout paraphyses, which are as a rule firmly agglutinated together. Spores elongate-oblong to clavate, 40–65 × 12–22 mmm.; apex truncate, rounded, or bluntly acuminate, often oblique, thickened up to 5 mmm., more deeply coloured than rest of spore, base attenuate, basal cell narrower, longer, and lighter in colour than upper; slightly constricted at septum; epispore smooth, chestnut-brown, 2 mmm. thick in upper, 1 mmm. thick in lower cell; pedicel persistent, continuous with spore, coloured, stout, short, up to 21 × 7 mmm.; germ-pore of upper cell apical, obscure, basal pore immediately below septum, obscure.

Host: *Secale cereale* L. On leaves and sheaths. Herb. No. 302. II, III. Ruakura (Auckland), *A. H. Cockayne!* 27 Jan., 1921.

Distribution: Australia; North America; Europe; Asia Minor.

The aecidia, which occur on several hosts belonging to different genera, have not been collected in New Zealand.

Opinions are divided as to whether this should be classified as one or several species. Eriksson and Henning (*l.c.*) divided *Puccinia rubigo-vera* Wint. into three—*P. glumarum*, *P. simplex*, and *P. dispersa*—on account of certain morphological differences, chiefly in the uredosori. Shortly afterwards Eriksson (1894, p. 292) showed by cultural experiments that *P. glumarum* and *P. dispersa* each consisted of five biological races.

In 1899 Eriksson divided the original *P. rubigo-vera* into seven species, as under :—

1. *P. glumarum* Erikss. et Henn.—on wheat and *Bromus* spp. Aecidia unknown.
2. *P. dispersa* Erikss.—on rye. Aecidia on *Anchusa* spp.
3. *P. Triticina* Erikss.—on wheat. Aecidia unknown.
4. *P. Bromina* Erikss.—on *Bromus* spp. Aecidia unknown. (F. Mueller (1901) found that the aecidia of this race occur on *Symphytum officinale* L., and for this reason changed *P. Bromina* Erikss. to *P. Symphyti-Bromorum* Muell.)
5. *P. Agropyrina* Erikss.—on *Triticum repens*. Aecidia unknown.
6. *P. Holcina* Erikss.—on *Holcus lanatus* and *H. mollis*. Aecidia unknown.
7. *P. Triseti* Erikss.—on *Trisetum flavescens*. Aecidia unknown.
8. *P. simplex* Erikss. et Henn.—on barley. Aecidia unknown. (It has since been shown that the aecidial stage occurs on *Ornithogalum* spp.)

Of these, three should be allowed specific rank, as they show morphological differentiation; the others are identical in appearance and (if we exclude the presence or absence of aecidia—an uncertain character, as the aecidia are in so many instances unknown) should be considered merely as biological races.

Arthur and Fromme (1920, p. 333) have shown that the forms named by Eriksson *Puccinia Agropyrina* and *P. Triticina* belong to another species, *Dicaeoma Clematidis* (DC.) Arth. (= *Puccinia Elymi* Westnd.).

3. **Puccinia graminis** Persoon. (Text-fig. 24, and Plate 77, fig. 4.)

Pers., *Disp. Meth.*, p. 39, 1797.

Lycoperdon poculiforme Jacq., *Coll.*, vol. 1, p. 122, 1786. *Aecidium Berberidis* Pers., in J. F. Gmel., *Syst. Nat.*, vol. 2, p. 1473, 1791. *A. lineare* Pers., *l.c.* *Puccinia culmorum* Schum., *Enum. Pl. Saell.*, vol. 2, p. 233, 1801. *Aecidium Berberidis-cylindricum* Rebent., *Prodr. Fl. Neom.*, p. 352, 1804. *Puccinia cerealis* H. Mart., *Fl. Mosq.*, p. 183, 1812. *Dicaeoma graminis* S. F. Gray, *Nat. Arr. Brit. Pl.*, vol. 1, p. 541, 1821. *Caeoma Berberidis* Schlecht., *Fl. Berol.*, vol. 2, p. 112, 1824. *C. beriberidatum* Link., in Willd., *Sp. Pl.*, vol. 6, p. 57, 1825. *Puccinia Anthoxanthi* Fcl., *Jahrb. Nass. Ver.*, vol. 27, p. 15, 1873. *P. poculiformis* Wettst., *Vehr. Zool.-Bot. Ges. Wien*, vol. 35, p. 544, 1886. *P. Phlei-pratensis* Erikss. et Henn., *Zeits. Pflanzenkr.*, vol. 4, p. 140, 1894. *P. jubata* Ellis and Barth., *Erythea*, vol. 4, p. 2, 1896. *Dicaeoma poculiforme* (Jacq.) Kuntze, *Rev. Gen.*, vol. 3, p. 466, 1898. *D. Anthoxanthi* Kuntze, *l.c.*, p. 467. *Puccinia vilis* Arth., *Bull. Torr. Cl.*, vol. 28, p. 663, 1901. *P. Sesleriae-coerulae* E. Fisch., *Beitr. Krypt. Schweiz.*, vol. 2, p. 259, 1904. *Dicaeoma vile* Arth., *Res. Sci. Congr. Bot. Vienne*, p. 344, 1906. *Uredo quinqueporula* Arth. and Fromme, *Torreya*, vol. 15. p. 265, 1915.

O. Spermogones amphigenous, crowded in small groups which are seated on circular discoloured spots, honey-coloured.

I. Aecidia hypophyllous, caulicolous, and fructicolous, in crowded circular, inflated groups, on discoloured spots, up to 5 mm. diam., yellow. Peridia at first cylindrical, becoming cupulate, margins white, erect, becoming slightly expanded, dentate. Spores polygonal, subglobose, or elliptical, 14–26 mmm. diam.; epispore hyaline, 1–5 mmm. thick, thickened at apex, up to 7 mmm., finely and densely verruculose, cell-contents sulphur-yellow.

II. Uredosori amphigenous, and on stems, sheaths, and glumes, reddish-brown, scattered, or more frequently confluent when linear, attaining a

length of 2–3 mm., bullate, pulverulent, becoming exposed by the epidermis rupturing longitudinally. Spores elliptical, often obovate, sometimes subglobose, 20–38 × 14–20 mmm.; epispore coarsely and moderately echinulate, 1·5–2 mmm. thick, golden-brown, with 3–4 equatorial germ-pores on one face.

III. Teleutosori on sheaths, stems, and inflorescences, seldom on blades, at first scattered, becoming confluent and linear, attaining a length of 12 mm. or more, pulvinate, compact, black, at first covered, becoming naked and conspicuous. Spores elliptical, oblong-clavate, or clavate, 35–70 × 15–25 mmm.; apex acuminate, sometimes oblique, thickened, up to 12 mmm., more deeply coloured than rest of spore, base attenuate, basal cell longer and narrower than upper; constricted at septum; epispore smooth, up to 3 mmm. thick, chestnut-brown, cell-contents granular, nuclei conspicuous; pedicel persistent, coloured, more deeply at apex, continuous with spore, up to 90 × 9 mmm., equally thick throughout; germ-pore of upper cell apical, conspicuous, basal pore immediately below septum, conspicuous.

X. Mesospores common, elliptical, 30–45 × 11–15 mmm.; apex acuminate, frequently rounded, thickened.

Hosts:—

Avena sativa L. On blades, culms, and inflorescences. Herb. No. 323. II. Marton (Wellington), *C. H. Schwass!* 16 Feb., 1921. II, III. Ruakura (Auckland), *G. H. C.* 28 Feb., 1921.

Dactylis glomerata L. On blades and culms. Herb. No. 395. II, III. Springfield (Canterbury), 500 m., *W. D. Reid!* 18 June, 1921.

Festuca elatior L. On culms, leaves, and sheaths. Herb. No. 332. II, III. Helensville (Auckland), *E. Bruce Levy!* 15 Feb., 1921.

Festuca pratensis Huds. On culms. Herb. No. 347. II, III. Gore (Otago), *R. B. Tennent!* 4 May, 1921.

Lolium perenne L. On culms and leaves. Herb. No. 347. II, III. Gore (Otago), *R. B. Tennent!* 4 May, 1921.

Triticum vulgare Vill. On blades, culms, and inflorescences. Herb. No. 299, 300. II, III. Ruakura (Auckland), *A. H. Cockayne!* 25 Jan., 1921. II. Canterbury, *F. E. Ward!* 18 Feb., 1921.

Lolium multiflorum Lam. On leaves and culms. II, III. Moumahaki (Wellington), *J. W. Deem!* 9 Jan., 1922. Ruakura (Auckland), *A. W. Green!* 9 Jan., 1922.

Lolium temulentum L. On leaves and inflorescences. II, III. Moumahaki (Wellington), *J. W. Deem!* 9 Jan., 1922.

Distribution: World-wide.

The aecidia, which occur on *Berberis* spp., have not been collected in New Zealand. In Australia, McAlpine (1906, p. 67) proved that the Australian forms would not infect barberry; yet, although this is the case, wheat-rust is as prevalent there as in any country in the world. This would show that the aecidial stage is not essential to the perpetuation of the species. How, then, is the rust carried over from year to year? Probably the most reasonable theory is that of the overwintering of uredospores on grasses; for, as has been shown by many experiments (Jacky, 1900; Bolley, 1898; Barclay, 1891), they are capable of remaining viable for a considerable period. It would appear that viability of uredospores is a matter of climate, as they appear to remain viable in warmer localities for a much longer period than in colder areas.

Recent work on the part of Stakman and Piemeisel (1917), and Stackman, Piemeisel, and Levine (1918), has shown that uredospores from grasses are capable of infecting cereals in the spring. For example, they showed (1917, p. 466) that uredospores from *Agropyron*, *Elymus*, and *Hordeum* would readily infect wheat.

Other theories have been put forward to account for this overwintering of the fungus—*e.g.*, that a perennial mycelium is present; but insufficient evidence was forthcoming in support, no mycelium being found in the host other than in the vicinity of uredosori. To account for epiphytotic recrudescences of wheat-rust, J. Eriksson (1897) propounded his remarkable mycoplasm theory, which (in brief) is to the effect that, in some manner not understood, the fungus is able to combine some of its protoplasm with that of the host, thus forming a symbiotic substance which he termed "mycoplasm." This mycoplasm is supposed to remain dormant in the leaf or seed until conditions become favourable, when the fungal elements become active, grow out into the leaf in the mycelial form, eventually giving rise to sori of uredospores! This remarkable hypothesis has been severely criticized by Marshall Ward (1903), who showed that the whole theory was based on a misinterpretation of the ordinary phenomena of uredospore infection.

It was with this species that de Bary (1865, p. 25) first proved that heteroecism existed in the rusts. Not only is this rust heteroecious, having its aecidia on one plant and its teleutospores on another, but is also known to consist of many biological races, each supposed to be incapable of infecting any host other than the one it occurs on.

For example, Eriksson (1894, p. 292) showed by numerous cultural experiments that this species consisted of a number of biological races (or, as he termed them, "*specialisierte Formen*"), as under:—

Puccinia graminis Pers. Aecidia on *Berberis vulgaris*.

1. f. *Secalis*—on rye.
2. f. *Avenae*—on oat.
3. f. *Tritici*—on wheat.
4. f. *Airae*—on *Aira caespitosa*.
5. f. *Agrostidis*—on *Agrostis* spp.
6. f. *Poae*—on *Poa* spp.

Carleton (1899), working with the same races in North America, obtained quite different results. He claims that there are but two biological races, as under:—

1. f. *Tritici*—on wheat, barley, cocksfoot, *Agrostis alba*, *Festuca gigantea*, *Koeleria cristata*, and *Hordeum murinum*.
2. f. *Avenae*—on *Avena sativa*, *A. fatua*, *A. pratensis*, *Hordeum murinum*, cocksfoot, *Koeleria cristata*, *Holcus mollis*, &c.

Jaczewski (1910, p. 321) from his cultural experiments obtained results which showed interrelationships between hosts quite distinct from Eriksson's.

Again, Freeman and Johnson (1911) found that uredospores of f. *Tritici* readily infected barley, but would not infect oats, and rarely rye; but by first infecting barley they could with the resultant uredospores taken from the barley readily infect rye, and with uredospores taken from the rye they could in turn infect oats, the barley and rye in these experiments acting as "bridging species."

Most of these results given above were obtained by using uredospores.

Arthur (1910, p. 228), after experimenting with teleutospores and aecidiospores, states: "Although in the uredinal stage this rust shows racial strains that inhibit the ready transfer from one species of host to

another . . . yet in the aecial stage racial strains play no part, and the barberry acts as a bridging host between each and every other gramineous host." In a later work Arthur and Fromme (1920, p. 295) include under this species races occurring on 97 different hosts (exclusive of the 8 aecidial hosts), belonging to 35 genera.

Stakman, Piemeisel, and Levine (1918), as the result of cultural work extending over a period of four seasons, are of the opinion that "bridging" does not occur; furthermore, they claim that the aecidium does not act as a bridging host, nor does it act as a reinvigorator of the rust.

It would appear that specialization is not as pronounced as Eriksson and others would have us believe; in fact, the conditions governing this specialization are so little understood, and the results obtained so contradictory, that little reliance can be placed on any arbitrary separation of biological races. This illustrates the inadvisability of basing species on biological distinctions alone, and strengthens Marshall Ward's contention that "no species can be accepted as valid until it is capable of definition in morphological terms" (1905, p. 18).

4. Puccinia Poarum Nielsen.

Niels., in *Botanisk. Tidsskrift*, vol. 3, p. 24, 1877.

Hosts:—

Poa annua L. On leaves. Herb. No. 314. II. Kelburn (Wellington), *G. H. C.* 3 Feb., 1921.

Poa pratensis L. On leaves. Herb. No. 286. II. Kelburn (Wellington), *G. H. C.* 12 Jan., 1921.

Distribution: Australia; North America; Europe; Japan.

As I have no teleutospore material from which to describe this species, I have merely recorded this rust, together with the hosts.

5. Puccinia simplex Eriksson and Henning. (Fig. 25.)

Erikss. et Henn., *Zeits. Pflanzenkr.*, vol. 4, p. 260, 1894.

Puccinia straminis simplex Koern., *Land. Forstw. Zeit.*, No. 50, 1865. *Uromyces Hordei* Niels., *Ugeskr. Landm.*, vol. 2, p. 567, 1874. *P. anomala* Rostr.: Thuem., *Fl.*, vol. 61, p. 92, 1878. *Aecidium ornithogaleum* Bubak, *Ann. Myc.*, vol. 3, p. 223, 1905. *Dicaeoma anomalum* (Rostr.) Arth. and Fromme, *N. Am. Fl.*, vol. 7, p. 339, 1920.

0. Spermogones amphigenous, in groups occupying large areas, honey-coloured.

I. Aecidia amphigenous, scattered. Peridia cupulate, opening by an apical pore. Spores elliptical, 18–30 mmm. diam., minutely and closely verruculose.

II. Uredosori amphigenous, seldom caulicolous, cinnamon-brown, scattered or confluent, up to to 2 mm. long, pulverulent, surrounded by the ruptured epidermis. Spores elliptical or obovate, 20–30 × 16–25 mmm.; epispore sparsely and finely echinulate, 1·5–2 mmm. thick, pallid brown, with 6 to 8 scattered germ-pores on one face, obscure.

III. Teleutosori amphigenous, scattered or confluent, elliptical, up to 1·5 mm. long, pulvinate, compact, black, long covered. Spores clavate to cuneiform, 50–65 × 20–25 mmm.; apex truncate, obtuse, or bluntly acuminate, thickened up to 6 mmm. or not thickened, base attenuate, basal cell longer, narrower, and lighter in colour than upper; slightly

constricted at the septum; epispore smooth, 1·5 mmm. thick, chestnut-brown; pedicel persistent, coloured, short, continuous with spore, up to 20 × 8 mmm.; germ-pore of upper cell apical, obscure, basal pore immediately below septum, obscure; paraphysate.

X. Mesospores more common than teleutospores, clavate, 30–50 × 20 mmm.

Host: *Hordeum vulgare* L. Herb. No. 322. II, III. Ruakura (Auckland), *G. H. C.* 28 Feb., 1921. Christchurch, *F. E. Ward!* 18 Feb., 1921. Otago, *W. B. Tennent!* 3 Mar., 1921. Weraroa (Wellington), *J. Beverley!* 3 Mar., 1921.

Distribution: Australia; North America; Europe.

This species is characterized by the prevalence of mesospores in the sori, and by the aecidia occurring on *Ornithogalum* spp. (they have not been collected in New Zealand), otherwise it is identical morphologically with *P. dispersa* Erikss. et Henn.

6. **Puccinia Sorghi** Schweinitz. (Fig. 26.)

Schw., *Trans. Am. Phil. Soc.*, ser. 11, vol. 4, p. 295, 1832.

Uredo Zeae Desmaz., *Ann. Sci. Nat.*, ser. 2, vol. 13, p. 182, 1840. *Puccinia Maydis* Bereng., *Atti. Sci. Ital.*, vol. 6, p. 475, 1845: *hyponym.* *P. Zeae* Bereng.: Klotzsch., *Herb. Viv. Myc.*, Suppl. 18, 1851. *Trichobasis Maydis* Niessl., *Abh. Nat. Ver. Bruenn.*, vol. 3, p. 114, 1865. *Aecidium Oxalidis* Thuem., *Flora*, vol. 59, p. 425, 1876. *A. Peyritschianum* Magnus, *Ber. Nat. Med. Ver. Innsbruck*, vol. 21, p. 34, 1894.

0. Spermogones amphigenous, sparse, in small groups, honey-yellow.

I. Aecidia hypophyllous, in small more or less circular groups, minute. Peridia cupulate, margins erect, hyaline, irregularly lacerate, or entire. Spores globose or elliptical, 18–26 × 13–19 mmm; epispore pale yellow, 1–1·5 mmm. thick, finely and closely verruculose.

II. Uredosori amphigenous, scattered, elliptical, up to 1 mm. long, or confluent, forming lines up to 5 mm., bullate, pulverulent, epidermis fissuring longitudinally. Spores globose or subglobose, 22–30 mmm. diameter; epispore finely and sparsely echinulate, 1·5–2 mmm. thick, cinnamon-brown, with 3 equatorial germ-pores on one face.

III. Teleutosori amphigenous, scattered, rarely confluent, elliptical, up to 2 mm. long, pulvinate, compact, black, soon naked. Spores elliptical, 30–42 × 16–24 mmm.; apex rounded, often bluntly acuminate, thickened, up to 10 mmm., base attenuate, frequently rounded, both cells the same size and colour; slightly constricted at the septum; epispore chestnut-brown, smooth, 2–2·5 mmm. thick; pedicel persistent, coloured, up to 80 × 8 mmm.; germ-pore of upper cell apical, conspicuous, basal pore immediately below septum, obscure.

Host: *Zea Mais* L. On leaves. Herb. No. 324. II. Ruakura (Auckland), *G. H. C.!* 28 Feb., 1921.

Distribution: Australia; North and South America; Africa; Europe.

The uredo stage alone had been collected in New Zealand. I am indebted to Mrs. F. W. Patterson, of the United States Department of Agriculture, Mycological Exchange, for teleutospore material from which the above description has been drawn up.

Arthur (1904, p. 64) proved that this is an heteroecious species. He sowed aecidiospores from *Oxalis cymosa* Small on maize-leaves, and in five days obtained spermogones and uredosori.

7. **Puccinia Caricis** Schroeter. (Fig. 27.) Cyperaceae (2).

Schroet., *Krypt. Fl. Schles.*, vol. 3, p. 327, 1887.

Aecidium Urticae Schum., *Enum. Pl. Saell.*, vol. 2, p. 222, 1803. *Uredo Caricis* Schum., *l.c.*, p. 231. *Caeoma Urticae* Schlecht., *Fl. Berol.*, vol. 2, p. 112, 1824. *C. urticatum* Link., in Willd., *Sp. Pl.*, vol. 6, p. 62, 1825. *Puccinia Urticae* Lagerh., *Mitt. Bad. Bot. Ver.*, vol. 2, p. 72, 1889. *Dicaeoma Urticae* Kuntze, *Rev. Gen.*, vol. 3, p. 467, 1898. *D. Caricis* Kuntze, *l.c.*, p. 468. *Puccinia Garrettii* Arth., *Bull. Torr. Cl.*, vol. 32, p. 41, 1905. *Uredo fatiscens* Arth., *Bull. Torr. Cl.*, vol. 42, p. 593, 1915. *Puccinia urticata* Kern., *Mycologia*, vol. 9, p. 214, 1917.

0. Spermogones amphigenous, conspicuous, in groups on discoloured spots, honey-coloured.

I. Aecidia amphigenous and caulicolous, scattered, or more frequently in crowded groups on discoloured inflated and distorted areas, orange-yellow. Peridia cupulate, margins spreading, revolute, lacerate, white. Spores globose or polygonal, 18–25 × 15–22 mmm.; epispore pale yellow, densely and finely verruculose, 1 mmm. thick, cell-contents orange-yellow.

II. Uredosori amphigenous, chiefly hypophyllous, scattered, elliptical, up to 0·5 mm. long, or confluent and linear, reaching a length of 1 cm. or more, pulverulent, bullate, cinnamon-brown, surrounded by the ruptured epidermis. Spores elliptical, frequently obovate, 24–32 × 18–25 mmm.; epispore golden-brown, sparsely and coarsely echinulate, 1·5–2 mmm. thick, with 2–3 equatorial germ-pores on one face.

III. Teleutosori amphigenous, chiefly hypophyllous, scattered, elliptical, up to 1 mm. long, or confluent, forming lines up to 5 mm., chocolate-brown, pulvinate, compact, surrounded by the ruptured epidermis. Spores clavate, 35–65 × 15–25 mmm.; apex rounded, sometimes bluntly acuminate, thickened, up to 12 mmm., base attenuate, basal cell longer, narrower, and lighter in colour than the upper; constricted at the septum; epispore smooth, chestnut-brown, 1·5–2 mmm. thick; pedicel persistent, continuous with the spore, coloured, stout, up to 54 × 10 mmm.; germ-pore of upper cell apical, obscure, basal pore immediately below septum, obscure.

X. Mesospores uncommon, elongate elliptical, 35–44 × 12–16 mmm.; apex thickened and bluntly acuminate.

Hosts :—

Urtica aspera Petrie. On leaves and stems. I. Macraes (Otago), 300 m., *W. D. Reid!* 2 Dec., 1921.

Urtica linearifolia (Hook. f.) Cockayne. On leaves, veins, petioles, and stems. Herb. No. 424. I. Swamp, Weraroa sandhills (Wellington), *E. H. Atkinson!* 20 Oct., 1921.

Carex Berggreni Petrie. On leaves. Herb. No. 365. II, III. Kinloch (Otago), 370 m., *W. D. Reid!* 2 May, 1921.

Carex Buchanani Berggr. On leaves. Herb. No. 366. II. Creek-bed, Dunstan Mountains (Otago), 300 m., *W. D. Reid!* 21 May, 1921.

Carex Colensoi Boott. On leaves. II, III. Glenorchy (Otago), *W. D. Reid!* 15 Dec., 1921.

Carex dipsacea Berggr. On leaves. Herb. No. 368. II. Tokomaru (Wellington), *E. H. Atkinson!* 1 Feb., 1921.

Carex Gaudichaudiana (Boott) Kunth. On leaves. II, III. Mount Judah (Otago), 900 m., *W. D. Reid!* 14 Dec., 1921.

Carex pumila Thunb. On leaves and culms. Herb. No. 370. II, III. Seashore, Wellington, *E. H. Atkinson!* 27 Jan., 1921.

Carex resectans Cheesm. On leaves. Herb. No. 366. II. Dunstan Mountains; Mount Judah (Otago), 900 m.; *W. D. Reid!* Feb., Dec., 1921.

Carex stellulata Good. On leaves. Herb. No. 365. II, III. Lake Harris Track (Otago), 1,140 m., *W. D. Reid!* 6 May, 1921.

Carex ternaria Forst. f. On leaves and culms. Herb. Nos. 367, 369. II, III. Seashore, Wellington Heads, *G. H. C.* 27 Jan., 1921.

Distribution: Australia; North America; Europe; Siberia; Japan.

All the hosts are indigenous, the majority being endemic (Cheeseman, 1906). Magnus in 1872 first showed that the aecidium on *Urtica* was a phase in the life-cycle of *P. Caricis*. Arthur and Kern (1920, pp. 352–69) describe nineteen species of *Puccinia* on *Carex;* of these the majority are separated on aecidial and uredospore characters, the former as the result of many cultural experiments. I have no doubt there are several species in New Zealand, as there is considerable variation in the uredospore characters. I prefer to group them under the one species until such time as I am able by cultural experiments to separate them, rather than to describe many uredo forms alone.

8. **Puccinia Unciniarum** Dietel and Neger. (Fig. 28.)

Diet. et Neg., *Engl. Bot. Jahrb.*, vol. 22, p. 351, 1896.

0, I. Unknown.

II. Uredosori amphigenous, scattered, minute, 0·5 mm. diam., circular, pulverulent, chestnut-brown, surrounded by the ruptured epidermis. Spores subglobose, elliptical, or often obovate, 23–30 × 17–25 mmm; epispore 2 mmm. thick, cinnamon-brown, finely and sparsely echinulate, with 3–4 scattered germ-pores on one face.

III. Teleutosori hypophyllous, minute, circular, 0·5 mm. diam., pulvinate, compact, dark chocolate-brown, soon naked. Spores elongate-oblong, frequently fusoid, 48–55 × 15–20 mmm.; apex rounded, rarely attenuate, thickened up to 10 mmm., base attenuate, basal cell narrower and somewhat longer than the upper; constricted at the septum; epispore

Fig. 28.—*Puccinia Unciniarum* Diet. et Neg. Uredo- and teleuto-spores from *Uncinia compacta* R. Br.

Fig. 29.—*Puccinia juncophila* Cke. et Mass. Uredo- and teleuto-spores from *Juncus vaginatus* R. Br.

Fig. 30.—*Puccinia obscura* Schroet. Uredo- and teleuto-spores from *Luzula campestris* DC.

Fig. 31.—*Puccinia Kirkii* sp. nov. Uredo- and teleuto-spores from *Rumex flexuosus* Sol.

Fig. 32.—*Puccinia tiritea* sp. nov. Uredo- and teleuto-spores from *Muehlenbeckia australis* (Forst. f.) Meissn.

Fig. 33.—*Puccinia Tetragoniae* McAlp. Teleutospores from *Tetragonia implexicoma* Hook. f.

Fig. 34.—*Puccinia clavata* Syd. Teleutospores from *Clematis foetida* Raoul.

Fig. 35.—*Puccinia contegens* sp. nov. Teleutospores from *Ranunculus multiscapus* Hook. f. *m* = mesospore. No. 5 is a small form of which about 5 per cent. are present in the sori.

Fig. 36.—*Puccinia inornata* sp. nov. Teleutospores from *Cardamine heterophylla* (Forst. f.) O. E. Schultz. No. 5 is germinating.

Fig. 37.—*Puccinia Reidii* sp. nov. Teleutospores from *Radicula* sp. ined.

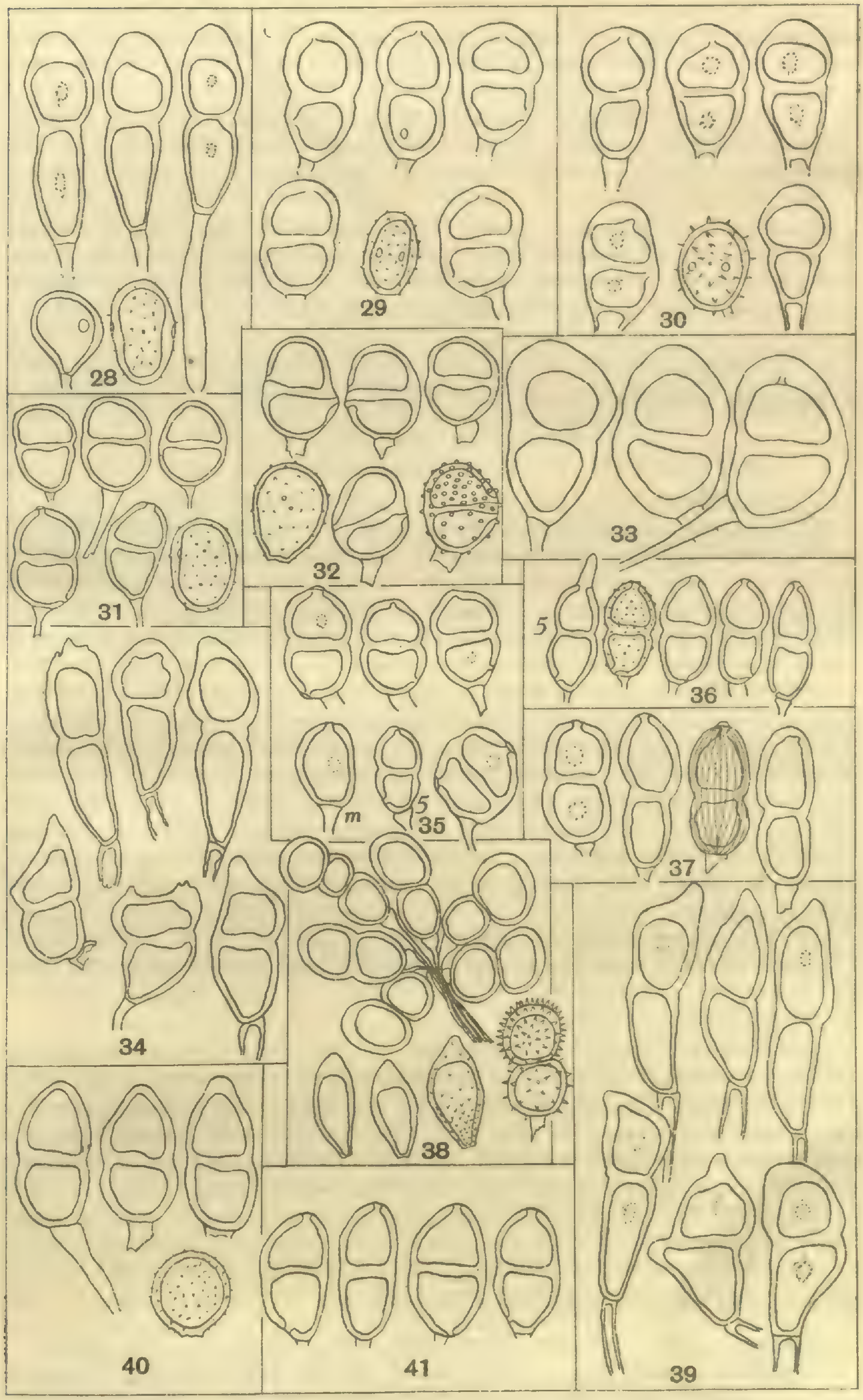
Fig. 38.—*Puccinia Pruni-spinosae* Pers. Uredo- and teleuto-spores from *Prunus domestica* L.; showing a group of teleutospores with their pedicels agglutinated together. A three-celled form is present.

Fig. 39.—*Puccinia Morrisoni* McAlp. Teleutospores from *Pelargonium inodorum* Willd.

Fig. 40.—*Puccinia granularis* Kalch. et Cke. Uredo- and teleuto-spores from *Pelargonium zonale* L'Herit.

Fig. 41.—*Puccinia Hoheriae* sp. nov. Teleutospores from *Hoheria populnea* A. Cunn.

Camera-lucida drawings by author. All × 500.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smooth, 1·5–2 mmm. thick, pale brown, cell-contents granular, nuclei conspicuous; pedicel persistent, tinted, up to 60 × 8 mmm., continuous with the spore; germ-pore of the upper cell apical, obscure, basal pore immediately below the septum, obscure.

X. Mesospores common, elliptical, 35–42 × 18 mmm.; epispore smooth.

Host: *Uncinia compacta* R. Br. On leaves. Herb. No. 352. II, III. Mount Dick; Kinloch (Otago), 840 m., *W. D. Reid!* April, May, 1921.

Distribution: Chile.

The host is indigenous, is widespread throughout the mountainous regions of both Islands (Cheeseman 1906, p. 800), and occurs also in Australia. This rust shows a general resemblance to *P. Caricis*, but the narrow fusoid teleutospore distinguishes it. It is apparently rare, and has hitherto been recorded only from Chile.

9. **Puccinia juncophila** Cooke and Massee. (Fig. 29.) Juncaceae (3).

Cke. et Mass., *Grev.*, vol. 22, p. 37, 1893.

Uredo armillata Ludw., *Bot. Centrabl.*, vol. 43, p. 8, 1890.

0, I. Unknown.

II. Uredosori amphigenous, cinnamon-brown, scattered when elliptical and 1 mm. long, or more commonly confluent and forming lines up to 10 mm. long, pulverulent, bullate, surrounded and partly covered by the ruptured epidermis. Spores subglobose, obovate, or elliptical, 22–32 × 15–22 mmm.; epispore coarsely and sparsely echinulate, yellowish-brown, 2–3 mmm. thick, with 2–3 equatorial germ-pores on one face.

III. Teleutosori amphigenous, elliptical, often confluent and up to 5 mm. long, pulverulent, chocolate-brown, surrounded by the ruptured epidermis. Spores elliptical, 30–40 × 20–28 mmm.; apex rounded, slightly (5–6 mmm.) or not thickened, base rounded, seldom subattenuate, both cells same size and colour, cell-contents granular; slightly constricted at the septum; epispore smooth, yellowish-brown, 3–4 mmm. thick; pedicel deciduous, hyaline, up to 50 × 5 mmm., often obliquely attached; germ-pore of upper cell apical, conspicuous, basal pore one-third to two-thirds below septum, obscure.

X. Mesospores uncommon, elliptical, or subglobose, 23–28 × 19–21 mmm.

Host: *Juncus vaginatus* R. Br. On leaves and culms. Herb. No. 262. II. Tokomaru (Wellington). 5 Nov., 1920. II, III. Tasman (Nelson), *G. H. C.* 17 Nov., 1921.

Distribution: Australia; Tasmania.

The uredo stage of this rust forms conspicuous cinnamon areas, often 10 mm. or more long, on the culms of the host. The teleutospores are uncommon and appear in the same sori as the uredospores. As the uredosori are invariably attacked by *Darluca filum* Cast., it is probable that this parasite largely prevents teleutospore-formation. I am indebted to Mr. C. C. Brittlebank, Melbourne, for specimens of this rust for comparative purposes.

10. **Puccinia obscura** Schroeter. (Fig. 30.)

Schroet.: Pass., *Nuovo. Giorn. Bot. Ital.*, vol. 9, p. 134, 1890.

Aecidium Bellidis Thuem., *Fungi Austr.*, No. 635, 1873: *hyponym. Puccinia Bellidis* Lagerh., *Bol. Soc. Broter.*, vol. 8, p. 134, 1890. *Dicaeoma obscurum* (Schroet.) Kuntze, *Rev. Gen.*, vol. 3, p. 469, 1898. *Puccinia Luzulae-maximae* Diet., *Ann. Myc.*, vol. 17, p. 57, 1919.

0. Spermogones amphigenous, numerous, scattered, honey-coloured.

I. Aecidia amphigenous, numerous, scattered. Peridia cupulate, margins erect, white, lacerate or entire. Spores polygonal, 16–22 mmm. diam.; epispore hyaline, 1–1·5 mmm. thick, moderately verruculose.

II. Uredosori hypophyllous, cinnamon-brown, scattered, elliptical, up to 1·5 mm. long, pulverulent, surrounded by the ruptured epidermis. Spores elliptical or commonly obovate, 22–30 × 18–23 mmm.; epispore coarsely and sparsely echinulate, 1·5 mmm. thick, golden-brown, with 2 equatorial germ-pores on one face.

III. Teleutosori hypophyllous, scattered, elliptical or circular, up to 1 mm. diam., pulverulent, chocolate-brown, surrounded by the ruptured epidermis. Spores clavate to elliptical, 25–40 × 15–22 mmm.; apex rounded, seldom attenuate, thickened up to 10 mmm., base attenuate, basal cell narrower than the upper, cell-contents granular, nuclei evident; constricted at the septum; epispore smooth, 1·5–2 mmm. thick, golden-brown; pedicel persistent, tinted, continuous with spore, stout, up to 25 × 8 mmm.; germ-pore of upper cell apical, conspicuous, basal pore immediately below septum, conspicuous.

Host: *Luzula campestris* DC. On leaves and culms. Herb. No. 371. II, III. Kinloch (Otago), 1,120 m.; Macraes (Otago), 600 m.; Mount Judah (Otago), 900 m.; Paradise (Otago), 400 m.; *W. D. Reid!* May, Nov., Dec., 1921.

Distribution: North America; Europe.

The aecidia of this species, which have not been found in New Zealand, occur on *Bellis perennis* L. Although an aecidium is abundant on this host in New Zealand, it is that of *Puccinia distincta* McAlp., as one commonly finds the teleutospores associated with the aecidia on the same host plant. McAlpine (1906, p. 137) describes a different rust on *Luzula* spp. in Australia. This species, *Puccinia tenuispora* McAlp., differs in the delicate, thin-walled, longer and narrower teleutospores, and in the colour of both uredo- and teleuto-spores, which in his specimens are much lighter. There is a close resemblance between the two, however. I am indebted to Mr. C. C. Brittlebank, Melbourne, for specimens of *Puccinia tenuispora* McAlp. for comparative purposes.

11. **Puccinia Kirkii** n. sp. (Fig. 31.) Polygonaceae (4).

0, I. Unknown.

II. Uredosori amphigenous, sparingly hypophyllous, cinnamon-brown, circular, scattered, pulverulent, 0·5 mm. diam., surrounded by the ruptured epidermis. Spores elliptical or obovate, 23–29 × 19–21 mmm.; epispore sparsely and coarsely echinulate, 1–1·5 mmm. thick, pale cinnamon-brown, with 3 scattered germ-pores on one face.

III. Teleutosori associated with and indistinguishable from the uredosori. Spores broadly elliptical, 25–33 × 19–22 mmm.; apex rounded, not thickened, base rounded, rarely attenuate, both cells same size and colour; slightly constricted at the septum; epispore smooth, 1 mmm. thick, light brown, cell-contents granular; pedicel deciduous, hyaline, fragile, up to 33 × 5 mmm.; germ-pore of upper cell apical, conspicuous, basal pore two-thirds way below septum, conspicuous, both frequently papillate.

X. Mesospores uncommon, obovate, 27 × 20 mmm.; apex rounded.

Hosts:—

Rumex neglectus T. Kirk. On leaves. Herb. No. 274. II, III. Sydney Cove (Stewart Island), *T. Kirk!* 12 Feb., 1882.

Rumex flexuosus Sol. On leaves. Dunstan Mountains (Otago), *W. D. Reid!* 5 Dec., 1921. II, III. Clinton Valley (Otago), *E. H. Atkinson!* 12 Jan., 1920. (Type.)

Both hosts are endemic; *R. flexuosus* closely resembles *R. Brownii* Campd., the host of *Puccinia Ludwigii* Tepp. McAlpine (1906, p. 173) mentions *R. flexuosus* as being a host of *P. Ludwigii*: there has been some mistake in the determination of this host, as according to Cheeseman (1906, p. 591) *R. flexuosus* does not occur in Australia.

This species is named in honour of the late Mr. T. Kirk, whose works on the flora of New Zealand are so well known to students of New Zealand botany. Mr. Kirk was also keenly interested in fungi, and despatched many specimens abroad. Through the kindness of Mr. T. W. Kirk, who gave me the fungous material collected by Mr. T. Kirk, including many cotype specimens, I have been enabled to verify many of my determinations of those fungi which have been named abroad.

An occasional three-celled spore is to be seen in the teleutosori, the upper cell being divided by a vertical septum. This species is characterized by the thin non-apiculate epispore of the teleutospore.

12. Puccinia tiritea n. sp. (Fig. 32.)

0. Spermogones epiphyllous, in scattered more or less circular groups, seated on yellow spots, minute, immersed, honey-brown.

II. Uredosori hypophyllous, scattered or arranged in irregular groups, not confluent, circular or elliptical, minute, 0·25–0·5 mm. diam., pulverulent, cinnamon-brown, surrounded by the ruptured epidermis. Spores obovate, 25–32 × 22–28 mmm.; epispore coarsely and sparsely echinulate, 1·5–2 mmm. thick, cinnamon-brown, with 2–3 scattered germ-pores on one face.

III. Teleutosori similar to and intermixed with the uredosori, chocolate-brown. Spores broadly elliptical, 25–32 × 17–25 mmm.; apex rounded, not thickened, base rounded, seldom attenuate, both cells same size and colour; epispore coarsely warted, more prominently on the upper cell, 1·5–2 mmm. thick, chestnut-brown; pedicel decidous, hyaline, short, up to 30 × 7 mmm.; germ-pore of upper cell immediately above the septum, conspicuous, basal pore immediately below septum, conspicuous.

Hosts:—

Muehlenbeckia australis (Forst. f.) Meissn. On leaves. Herb. No. 382. II, III. Tiritea, Palmerston North (Wellington), 300 m., *G. H. C.* 3 Mar., 1921. (Type.) II, III. Kingston (Otago), 400 m., *W. D. Reid!* 22 April, 1921. Turakina (Wellington), *Mrs. M. Cunningham.* 3 Jan., 1922.

Muehlenbeckia complexa (A. Cunn.) Meissn. On leaves. Herb. Nos. 381, 396. II, III. Kingston; Table Bay; Dunstan Mountains (Otago), 300–700 m., *W. D. Reid!* April, May, 1921.

Both hosts are endemic and widely distributed throughout New Zealand (Cheeseman, 1906, p. 592). This species may readily be distinguished by the coarsely warted epispore of the teleutospore. Another peculiar feature is the position of the germ-pores, which are situated immediately above and below the septum. This is an unusual position, and does not occur in any other New Zealand species. Garrett (1910) records this peculiarity in *Puccinia poromera* Holw., a rust occurring on *Angelica dilitata* Holw., in North America. This rust is quite distinct from *P. Muehlenbeckiae* Syd., which in Australia occurs on *Muehlenbeckia adpressa* Meissn., differing chiefly in the teleutospores being coarsely warted and not thickened at the apex.

13. Puccinia Tetragoniae McAlpine. (Fig. 33.) Aizoaceae (5).

McAlp., *Agr. Gaz. N.S.W.*, vol. 6, p. 854, 1895.

0. Spermogones amphigenous, aggregated, numerous, honey-coloured.

I. Aecidia hypophyllous, crowded in irregular groups which are often linear. Peridia cylindrical, up to 0·5 mm. diam., margins white, lacerate, expanded. Spores globose, obovate, 27–39 × 22–25 mmm.; epispore hyaline, minutely and densely verruculose, 2 mmm. thick, cell-contents vacuolate, orange-yellow.

II. Uredosori amphigenous, circular, scattered, bullate, pulverulent, 1–1·5 mm. diam., surrounded and partially covered by the ruptured epidermis. Spores elliptical to obovate, 27–37 × 22–25 mmm.; epispore pallid yellow, 3 mmm. thick, densely and coarsely echinulate, cell-contents orange-yellow, with 4–5 scattered germ-pores on one face.

III. Teleutosori amphigenous, arranged in circinnate groups, circles attaining a diam. of 5 mm., or scattered when elliptical and up to 4 mm. long, bullate, compact, black, long covered by the epidermis. Spores elliptical or subclavate, 40–60 × 25-26 mmm.; apex rounded, seldom acuminate, thickened up to 8 mmm., or not thickened, base rounded, seldom attenuate, both cells same size and colour, lower cell sometimes slightly narrower, cell-contents granular; slightly constricted at the septum; epispore smooth, chestnut-brown, up to 5 mmm. thick; pedicel persistent, hyaline, stout, up to 35 × 8 mmm.; germ-pore of the upper cell apical, obscure, basal pore immediately below the septum, obscure.

X. Mesospores uncommon, elliptical, 35–54 × 25–29 mmm.

Host: *Tetragonia trigyna* Banks et Sol. On leaves. Herb. No. 287. II. York Bay (Wellington), *E. H. Atkinson!* 24 Jan., 1921.

Distribution: Victoria; Tasmania.

The host is endemic, although Cheeseman (1906, p. 192) states that it is probably identical with the Australian *T. implexicoma* Hook. f.

A characteristic feature of this species is the large size, and the greatly thickened epispore of the teleutospores. I am indebted to Mr. C. C. Brittlebank for specimens of this rust for comparative purposes.

14. Puccinia clavata Sydow. (Text-fig. 34, and Plate 77, fig. 5.) Ranunculaceae (6).

Syd., *Mon. Ured.*, vol. 1, p. 428, 1904.

0. Spermogones amphigenous, scattered, seated on yellow spots, surrounded by the aecidia, honey-yellow.

I. Aecidia hypophyllous, aggregated on more or less orbicular yellow spots up to 3 mm. in diam., circinnately arranged, pallid yellow. Peridia up to 450 mmm. diam., tubular, erumpent, standing above leaf-surface 500–600 mmm., margins slightly expanded, dentate. Spores subglobose or polygonal, 20–27 × 18–22 mmm.; epispore minutely and closely verruculose, tinted, 1·5 mmm. thick, cell-contents granular, pallid yellow, 2–4 scattered germ-pores on one face.

II. Uredosori hypophyllous, lemon-yellow, elliptical, up to 1 mm. long, scattered, pulverulent, exposed by the longitudinal fissuring of the epidermis. Spores subglobose, elliptical, or obovate, 20–28 × 12–20 mmm.; epispore densely and coarsely verruculose, cream-coloured, 2·5–3 mmm. thick, hyaline, with 7–10 scattered germ-pores on one face.

III. Teleutosori hypophyllous, on small discoloured spots which are visible on the upper surface, black, circular, scattered, pulvinate, compact,

up to 2 mm. diam., long covered. Spores clavate, 45–62 × 12–22 mmm.; apex acuminate, rounded, or truncate, thickened up to 12 mmm., darker in colour than the rest of the spore, base attenuate, basal cell longer, narrower, and lighter in colour than upper; constricted at the septum; epispore smooth, pallid brown, 2·5–3 mmm. thick in apical cell, 1·5–2 mmm. in basal, cell-contents vacuolate; pedicel persistent, coloured, short, up to 21 × 7 mmm.; germ-pore of the upper cell apical, obscure, basal pore immediately below septum, obscure.

Hosts:—

Clematis foetida Raoul. On leaves. Herb. No. 269. III. Weraroa; Lake Papaetonga, Levin (Wellington), *E. H. Atkinson!* Sept., Nov., 1919.

Clematis hexasepala DC. On leaves. I. Levin (Wellington), *E. H. Atkinson!* 12 Feb., 1919. III. No locality given. *Bastian* (Syd.).

Clematis indivisa Willd. On leaves of juvenile plants. I, II. Sandhills, Levin (Wellington), *E. H. Atkinson!* 13 Nov., 1919. II. Motupiko River (Nelson), 500 m., *H. H. Allan!* 5 Jan., 1921.

The hosts are endemic, and distributed over both Islands (Cheeseman, 1906, pp. 2–4). In his original description, Sydow describes the teleutostage alone; but as all three stages occur on the same genus of host plant, and as more than one stage has been collected on the same species, and all three stages in or near the same locality, I have grouped all three under the one species. The teleutospores are very irregular in shape, and one commonly finds the pedicel laterally inserted.

But one other rust occurs on indigenous species of *Clematis* in New Zealand—namely, *Aecidium otagense* Lindsay. This differs mainly in the larger size of the aecidia, and in its habit of forming large, inflated, and distorted areas on the host (Plate 77, fig. 2).

15. Puccinia contegens n. sp. (Fig. 35.)

0. Spermogones amphigenous, sparse, associated with the aecidia, honey-coloured.

I. Aecidia hypophyllous, in crowded groups, yellow. Peridia immersed, margins incurved and partially covered with the epidermis, opening by an irregular pore. Spores polygonal or elliptical, 17–26 × 15–18 mmm.; epispore hyaline, 2 mmm. thick, densely and minutely verruculose, cell-contents orange, vacuolate.

III. Teleutosori amphigenous, chestnut-brown, pulverulent, at first scattered, circular, and surrounded by the ruptured epidermis, becoming confluent, frequently the entire under-surface of the leaf becoming covered. Spores elliptical or subclavate, 30–45 × 16–23 mmm.; apex rounded, sometimes obliquely acuminate, not thickened, base rounded, less frequently attenuate, both cells same size and colour; slightly or not constricted at the septum; epispore 1–1·5 mmm. thick, reticulate, more prominently on the upper cell, chestnut-brown, cell-contents vacuolate; pedicel persistent, hyaline, fragile, up to 60 × 7 mmm., sometimes laterally attached; germ-pore of upper cell apical, conspicuous, basal pore two-thirds below septum, conspicuous, both frequently papillate.

X. Mesospores uncommon, obovate or subglobose, averaging 22 × 18 mmm.; epispore reticulate, 1 mmm. thick, chestnut-brown.

Hosts:—

Ranunculus lappaceus Smith. On leaves. Herb. No. 284. III. Glen Wye, Hanmer (Canterbury), *W. D. Reid!* 26 Oct., 1919. Mount Judah (Otago), 500 m., *W. D. Reid!* 14 Dec., 1921.

Ranunculus multiscapus Hook. f. On leaves. III. Burke's Pass (Canterbury), *W. D. Reid!* 18 Nov., 1919. I, III. Macraes (Otago), *W. D. Reid!* 28 Nov., 1921. (Type.) Mount Torlesse (Canterbury), *W. D. Reid!* Feb., 1921. III. Mount Judah (Otago), 800 m., *W. D. Reid!* 25 Dec., 1921.

Both the hosts are indigenous; *R. lappaceus* occurs also in Australia (Cheeseman, 1906, p. 20). About 5 per cent. of small spores are present in the teleutosori; these are similar to the normal spores save in size, which is considerably less than normal, being on the average 25 × 15 mmm. (fig. 35, No. 5). Occasionally a vertical septum is present in the upper cell. Characterized by the non-thickened apex, and reticulate epispore of the teleutospore.

16. **Puccinia inornata** n. sp. (Fig. 36.) Cruciferae (7).

0. Unknown.

III. Teleutosori amphigenous and caulicolous, circular or elliptical, scattered, becoming confluent, up to 1·5 mm. long, cinnamon-brown, pulverulent, surrounded by the ruptured epidermis, causing the hosts to become distorted and stunted. Spores elliptical, 23–35 × 12–16 mmm.; apex rounded or bluntly acuminate, not thickened, base rounded, both cells same size or the lower often somewhat narrower; constricted at the septum; epispore minutely warted, 1·5–2 mmm. thick, pallid brown; pedicel deciduous, hyaline sometimes tinted, short, up to 20 × 5 mmm.; germ-pore of upper cell apical, conspicuous, frequently papillate, basal pore immediately above pedicel, conspicuous.

Host: *Cardamine heterophylla* (Forst. f.) O. E. Schulz. On leaves, petioles, and stems. Herb. No. 444. III. Macraes (Otago), 600 m., *W. D. Reid!* 29 Nov., 1921. (Type.)

This rust is very conspicuous, as it distorts and stunts the host; where infection is severe the plant appears as if covered with a cinnamon-brown powder. The host is indigenous and widespread; it appears to be common in other countries. This rust is characterized by the distorting habit and by the warted epispore. Another constant feature is the position of the basal germ-pore, which is situated immediately above the pedicel.

17. **Puccinia Reidii** n. sp. (Fig. 37.)

0. Spermogones amphigenous, preceding sori, on discoloured spots, scattered, or in sparse groups, immersed, honey-yellow.

III. Teleutosori amphigenous and caulicolous, elliptical, scattered, up to 1 cm. long, bullate, pulverulent, black, long covered, finally becoming exposed by the longitudinal fissuring of the epidermis. Spores ellipticoblong, 32–42 × 15–22 mmm.; apex rounded, rarely acuminate, not thickened, base rounded, both cells same size and colour, cell-contents granular; constricted at the septum; epispore chestnut-brown, 3 mmm. thick, markedly longitudinally striate, striae converging at the poles; pedicel deciduous, hyaline, up to 45 × 6 mmm.; germ-pore of the upper cell apical, or sometimes one-fourth way down side, conspicuous, basal pore immediately below septum, conspicuous, both usually papillate.

Host: *Radicula* sp. ined. On leaves, petioles, and stems. Herb. No. 378. III. Walter Peak (Otago), *W. D. Reid!* 27 April, 1921. (Type.)

The host, together with the rust, was collected by Dr. Cockayne and his assistant, Mr. W. D. Reid. The host proved to be an undescribed

species; it appears to be rare, and confined to the one locality. The rust is named in honour of Mr. Reid, who has collected the major number of the specimens in my herbarium. Mr. Reid has had excellent opportunities for collecting; as assistant to Dr. Cockayne he has traversed practically the whole mountain-chain of the South Island, and has never failed to send interesting material, excellently preserved, from the localities visited. Moreover, all host plants forwarded have been determined by Dr. Cockayne, so that I have been fortunate in having all the host plants collected by Mr. Reid correctly named.

This species is characterized by the thick longitudinally-striate epispore of the teleutospore.

18. Puccinia Pruni-spinosae Persoon. (Text-fig. 38, and Plate 77, fig, 6.)
Rosaceae (8).

Pers., *Syn. Fungi*, p. 226, 1801.

Aecidium punctatum Pers., *Ann. Bot. Usteri*, vol. 20, p. 135, 1796. *Puccinia Pruni* DC., *Fl. Fr.*, vol. 2, p. 222, 1805. *Aecidium quadrifidum* DC., in Poir., *Encycl. Meth. Bot.*, vol. 8, p. 235, 1808. *Puccinia Prunorum* Link., in Willd., *Sp. Pl.*, vol. 6, p. 82, 1825. *Uredo fusiformis* Gachet, *Act. Soc. Linn. Bordeaux*, vol. 5, p. 232, 1832. *Aecidium hepaticum* Schw., *Trans. Am. Phil. Soc.*, ser. 2, vol. 4, p. 293, 1832. *Uredo Pruni* Cast., *Obs. Myc.*, vol. 1, p. 27, 1842. *Uromyces Prunorum* Fcl., *Jahrb. Ver. Nat. Nass.*, vol. 15, p. 20, 1861. *Dicaeoma Prunorum* Rabh., *Fungi Eur.*, No. 990, 1866. *Puccinia discolor* Fcl., *Symb. Myc.*, No. 50, 1869. *Dicaeoma Pruni-spinosae* Kuntze, *Rev. Gen. Pl.*, vol. 3, p. 470, 1898. *Aecidium dakotensis* Griff., *Bull. Torr. Cl.*, vol. 29, p. 300, 1902. *A. Aikeni* Syd., *Ann. Myc.*, vol. 1, p. 334, 1903. *Tranzschelia punctata* (Pers.) Arth., *Res. Sci. Congr. Bot. Vienne*, p. 340, 1906.

0. Spermogones amphigenous, scattered, conspicuous, honey-coloured.

I. Aecidia hypophyllous, scattered. Peridia at first cylindrical, dehiscing into 3–5 lobes which lie parallel with the leaf-surface, margin broad, revolute, or more commonly flat. Spores subglobose, 18–26 × 15–23 mmm.; epispore closely and minutely verruculose, 1·5–2 mmm. thick, cinnamon-brown.

II. Uredosori hypophyllous, grouped on scattered yellow spots which are visible on the upper surface, cinnamon-brown, circular, pulverulent, up to 0·5 mm. diam., surrounded by the ruptured epidermis. Spores somewhat bluntly fusiform, 25–38 × 12–18 mmm.; epispore sparsely and coarsely verrucose, more prominently below, 1·5 mmm. thick, apex thickened up to 9 mmm. and bluntly acuminate, with 2–3 equatorial germ-pores on one face; intermixed with numerous capitate pale-yellow paraphyses, which may reach a size of 60 × 16 mmm.

III. Teleutosori hypophyllous, dark chestnut-brown, circular, scattered, pulverulent, up to 1 mm. diam., surrounded by the ruptured epidermis. Spores oblong, elliptical, or somewhat obovate, 30–40 × 18–26 mmm.; apex rounded, thickened up to 6 mmm., seldom not thickened, base rounded, basal cell usually narrower and lighter in colour than the upper, both semiglobose and readily separable; deeply constricted at the septum; epispore closely and coarsely verrucose, 1·5–2 mmm. thick, thinner in lower cell, chestnut-brown; pedicel deciduous, hyaline, fragile; germ-pore of upper cell apical, obscure, basal pore one-third way below septum, obscure, frequently papillate.

Hosts:—

Anemone sp. cult. On leaves. Herb. No. 437. I. Christchurch (Canterbury), *W. K. Dallas!* 27 Nov., 1921.

Prunus amygdalus Stokes. On leaves. Herb. No. 183. II. Clyde (Otago), *G. H. C.* 7 Nov., 1919.

Prunus armeniaca L. On leaves. II. Cromwell (Otago), *G. H. C.* 5 Nov., 1919.

Prunus domestica L. On leaves. II, III. Palmerston North (Wellington), *G. H. C.* 18 June, 1919.

Prunus persica Stokes. On leaves. II. Weraroa (Wellington), *G. H. C.* 21 May, 1919.

Distribution: Australia; North and South America; Europe; Africa.

This is an heteroecious species, the aecidia occurring on *Anemone* spp.; this connection was first worked out by Tranzschel (1904). The mycelium of the aecidia is perennial, and infected leaves are somewhat paler in colour and frequently much distorted. From the aecidia, spores are produced which infect the leaves of peaches, plums, &c., growing in the vicinity. On these leaves uredospores are produced, followed later in the season by teleutospores. As viable uredospores are to be obtained nine months of the year, it is probable that this rust is spread chiefly by these spores. This will appear more evident when one considers the fact that the aecidial host is an introduced species and is found in but a few localities; yet this rust is prevalent throughout New Zealand on stone-fruits. McAlpine (1902, p. 23) describes and figures this fungus attacking the fruit and cortex of a peach-tree. On the bark large irregular cankered areas were formed, and sori of the rust were found deeply embedded in the mesocarp of the fruits.

When the teleutosori are examined under a low power the spores are seen to be aggregated together in globose masses; higher magnification shows that the pedicels of the spores are firmly agglutinated together. McAlpine appears to have been the first to record this peculiarity (1904, p. 348), and it forms one of the characters on which Arthur (1907, p. 150) erected the genus *Tranzschelia.*

Characterized by the fusoid, verrucose uredospores, and strongly warted teleutospores. The grouping of the spores in globose masses is another feature peculiar to this species.

19. **Puccinia granularis** Kalchbrenner and Cooke. (Text-fig. 40, and Plate 77, fig. 7.) Geraniaceae. (9).

Kalch. et Cke., *Grev.*, vol. 11, p. 22, 1883.

0, I. Unknown.

II. Uredosori amphigenous and sparingly caulicolous, at first scattered, minute, circular, becoming confluent and somewhat circinnate, up to 3 mm. diam., pulverulent, chestnut-brown, surrounded by the ruptured epidermis. Spores globose to obovate, 21–28 × 18–24 mmm.; epispore sparsely and somewhat finely echinulate, 2–2·5 mmm. thick, thickened at base to 3 mmm., cinnamon-brown, with 2 germ-spores on one face.

III. Teleutosori hypophyllous, surrounding uredosori, chocolate-brown, bullate, compact, circinnate, circles may attain a diam. of 3 cm., long covered. Spores elongate-elliptical, oblong, or clavate, 37–48 × 19–23 mmm.; apex bluntly rounded, truncate, often oblique, slightly (4 mmm.) or not thickened, base attenuate, frequently rounded; constricted at the septum; epispore smooth, 2·5–3 mmm. thick, chestnut-brown, darker above; pedicel persistent, fragile, short, up to 50 × 8 mmm.; germ-pore of upper cell apical, obscure, basal pore immediately below septum, obscure.

Host: *Pelargonium zonale* L'Herit. On leaves, petioles, and stems. Herb. No. 283. II. Palmerston North (Wellington), *G. H. C.* 4 June, 1919.

II, III. York Bay (Wellington), *E. H. Atkinson!* 1 Feb., 1921. Napier (Hawke's Bay), *J. Anderson!* 12 Nov., 1921.

Distribution: South Africa; Australia.

Common on cultivated pelargoniums throughout New Zealand. Recognized by the marked circinnate grouping of the teleutosori (see Plate 77, fig. 7), and scarcely thickened apex and smooth epispore of the teleutospores. *Puccinia Pelargonii* Syd. is separated from this species solely on account of the presence of aecidia in the cycle. In all other respects it appears to be identical. I am indebted to Dr. E. W. Mason, of the Imperial Bureau of Mycology, Kew, for the correct determination of this species.

20. Puccinia Morrisoni McAlpine. (Fig. 39.)

McAlp., *Rusts Aus.*, p. 180, 1906.

0. Unknown.

I. Aecidia amphigenous, either alone or accompanied by teleutospores, delicate, circinnate, orange, minute. Peridia with expanded and lobed margins. Spores elliptical to subquadrate, 19–22 × 16 mmm.; epispore finely echinulate.

II. Uredosori amphigenous, cinnamon-brown, circular, scattered or arranged in confluent groups, pulverulent, up to 1 mm. diam., surrounded by the ruptured epidermis. Spores subglobose or elliptical, 22–28 × 15–22 mmm.; epispore sparsely and somewhat coarsely echinulate, 2 mmm. thick, golden-brown, with 2 germ-pores on one face.

III. Teleutosori amphigenous and caulicolous, chocolate-brown, circular, on stems elliptical, scattered, or arranged in confluent groups, pulvinate, compact, up to 2 mm. diam., surrounded by the ruptured epidermis. Spores clavate, 36–68 × 18–25 mmm.; apex acuminate, truncate, or often oblique, thickened up to 10 mmm., darker in colour, base attenuate, basal cell longer, narrower, and lighter in colour than upper; constricted at the septum; epispore smooth, 2–2·5 mmm. thick in upper cell, 1–1·5 mmm. in lower, chestnut-brown, cell-contents granular, nuclei evident; pedicel persistent, tinted, darker in colour at apex, stout, up to 38 × 9 mmm.; germ-pore of upper cell apical, conspicuous, basal pore immediately below septum, obscure, occasionally papillate.

X. Mesospores common, elliptical, 32–36 × 17–20 mmm.; apex rounded, truncate, or acuminate, thickened.

Host: *Pelargonium inodorum* Willd. On leaves and stems. Herb. No. 272. II, III. Cluny, Turakina (Wellington), *G. H. C.* 25 Dec., 1920. II, III. Seashore near Pencarrow (Wellington), *E. H. Atkinson!* 10 Feb., 1921.

Distribution: Australia; Tasmania.

The host is indigenous, and occurs also in Australia, Tasmania, and Tristan d'Acunha. Cheeseman (1906, p. 91) states that it is probably identical with *P. grossularioides* Ait., a South African species. So far the aecidial stage has not been collected in New Zealand. This species differs from the preceding in the possession of a larger teleutospore, more thickened at the apex.

21. Puccinia Plagianthi McAlpine. (Plate 77, fig. 8.) Malvaceae (10).

McAlp., *Proc. Roy. Soc. Vic.*, vol. 7 (n.s.), p. 218, 1894.

0. Spermogones amphigenous, in scattered groups on yellow spots, erumpent, honey-coloured.

III. Teleutosori amphigenous, chiefly hypophyllous, seated on yellow spots, circular, pulverulent, chestnut-brown, minute, scattered, up to 0·5 mm. diam., surrounded by the ruptured epidermis. Spores elliptical, seldom subclavate, 33–45 × 15–21 mmm.; apex rounded, not or slightly thickened, base subattenuate or rounded, both cells same size and colour; constricted at the septum; epispore finely reticulate, 1·5–2 mmm. thick, golden-brown, cell-contents vacuolate; pedicel deciduous, hyaline, short, up to 60 × 7 mmm.; germ-pore of upper cell apical, conspicuous, basal pore immediately above the pedicel, conspicuous.

Hosts :—

Gaya Lyallii (Hook. f.) J. E. Baker. On leaves. Herb. No. 280. III. Clinton Valley (Otago), *E. H. Atkinson!* 19 Jan., 1920.

Plagianthus betulinus A. Cunn. On leaves and inflorescences. Herb. No. 290. III. Masterton (Wellington), *G. H. C.* 14 Jan., 1919. Upper Hutt (Wellington), *E. H. Atkinson!* 23 Jan., 1921. Palmerston North (Wellington), *G. H. C.* 3 Mar., 1921.

Distribution: Tasmania.

Both hosts are endemic, *Gaya Lyallii* being confined to the South Island (Cheeseman, 1906, pp. 77–80). Distinguished by the elliptical teleutospores with their reticulate epispores. *P. Hoheriae* is separated from this species on account of the differences in sorus characters.

22. Puccinia Hoheriae n. sp. (Text-fig. 41, and Plate 77, fig. 9.)

0. Spermogones epiphyllous, sparse, in scattered groups on pallid spots, minute, immersed, honey-coloured.

III. Teleutosori amphigenous, chiefly hypophyllous, and caulicolous, on leaves scattered, when elliptical, seated on purple spots, but more frequently aggregated into irregular masses up to 40 mm. long, forming distorted areas which on the opposite surface are ashy-grey and surrounded by broad purple margins, on stems forming large, irregular, distorted and inflated areas which may attain a length of 50 mm., dark chestnut-brown, pulverulent.

Teleutospores as in *P. Plagianthi.*

Host: *Hoheria populnea* A. Cunn. On leaves, petioles, and shoots. Herb. Nos. 182, 423. III. Karori (Wellington), *R. Waters!* 8 Dec., 1920. (Type.) Palmerston North (Wellington), *J. W. Whelan!* 7 Sept., 1921. Manawatu Gorge (Wellington), *J. W. Whelan!* 2 Nov., 1921.

The host is endemic and widespread. It is with considerable hesitation that I have raised this well-marked form to specific rank, as it differs from *P. Plagianthi* only in sorus characters; these, however, are so well marked that to the eye there appears to be no resemblance whatever between the two. It is only when the teleutospores are examined under the microscope that the relationship of the two forms becomes apparent. (See Plate 77, figs. 8, 9.)

23. Puccinia Malvacearum Bertero. (Fig. 42.)

Bert., in C. Gay, *Fl. Chile*, vol. 8, p. 43, 1852.

0. Unknown.

III. Teleutosori amphigenous, chiefly hypophyllous, and caulicolous, seated on discoloured spots, on leaves circular, on stems elliptical, scattered, cinnamon-brown, pulvinate, compact, up to 1·5 mm. diam., at first covered, soon naked. Spores fusiform, 40–90 × 14–24 mmm.; apex

bluntly acuminate, seldom rounded, thickened up to 10 mmm., base attenuate, both cells same size and colour; slightly constricted at the septum; epispore smooth, 2–3 mmm. thick, pallid brown, cell-contents vacuolate; pedicel persistent, hyaline, long, stout, up to 160 × 10 mmm., continuous with spore; germ-pore of upper cell apical, conspicuous, basal pore immediately below septum, conspicuous, frequently papillate.

X. Mesospores rare, fusiform, 30–45 × 17–19 mmm.; apex thickened.

Hosts:—

Althaea rosea (L.) Cav. On leaves, petioles, and stems. Herb. No. 23. III. Turakina (Wellington), *G. H. C.* 5 July, 1919. Napier (Hawke's Bay), *H. Hill!* 5 Sept., 1921.

Malva rotundifolia L. On leaves and petioles. III. Willis Street, Wellington, *T. Kirk!* 1880.

Malva sylvestris L. On leaves. III. Botanical Gardens, Dunedin, *T. Kirk!* 30 Dec., 1884.

Distribution: Australia; North and South America; Europe; Asia.

All the hosts are introduced. The sori and spores vary considerably in size on different hosts. McAlpine (1906, p. 179) states that he has occasionally found a septate pedicel. The teleutospore germinates immediately on reaching maturity; it would appear that a few are capable of remaining viable throughout the winter, however, giving rise to fresh infection in the spring.

Characterized by the smooth, fusiform teleutospores.

24. Puccinia Hederaceae McAlpine. (Fig. 43.) Violaceae (11).

McAlp., *Rusts Aus.*, p. 183, 1906.

0. Spermogones amphigenous, crowded in small or large groups, honey-coloured.

I. Aecidia amphigenous, and on petals and flowers, in crowded groups, or seldom scattered. Peridia cupulate, 0·5 mm. diam., immersed, margins

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Fig. 42.—*Puccinia Malvacearum* Bert. Teleutospores from *Althaea rosea* Cav.

Fig. 43.—*Puccinia Hederaceae* McAlp. Uredo- and teleuto-spores from *Viola Cunninghamii* Hook. f. No. 6 shows a vertical septum.

Fig. 44.—*Puccinia Halorrhagidis* sp. nov. Uredo- and teleuto-spores from *Halorrhagis erecta* (Murr.) Schindler. No. 4 is three-celled.

Fig. 45.—*Puccinia pulverulenta* Grev. Uredo- and teleuto-spores from *Epilobium novae-zelandiae* Hausskn.

Fig. 46.—*Puccinia cuniculi* sp. nov. Uredo- and teleuto-spores from *Angelica Gingidium* Hook. f.

Fig. 47.—*Puccinia Hydrocotyles* Cke. Uredo- and teleuto-spores from *Hydrocotyle novae-zelandiae* DC. and *H. moschata* Forst. f. Nos. 4 and 5 are from the latter host.

Fig. 48.—*Puccinia kopoti* sp. nov. Uredo- and teleuto-spores from *Anisotome aromatica* Hook. f.

Fig. 49.—*Puccinia Oreomyrrhidis* sp. nov. Teleutospores from *Oreomyrrhis andicola* Endl. No. 4 is a small form of which there is about 1 per cent. present in a sorus.

Fig. 50.—*Puccinia Thuemeni* McAlp. Uredo- and teleuto-spores from *Apium prostratum* (DC.) Lab.

Fig. 51.—*Puccinia Cockaynei* sp. nov. Teleutospores from *Gentiana corymbifera* T. Kirk.

Fig. 52.—*Puccinia tararua* sp. nov. Uredo- and teleuto-spores from *Gentiana patula* Cheesem.

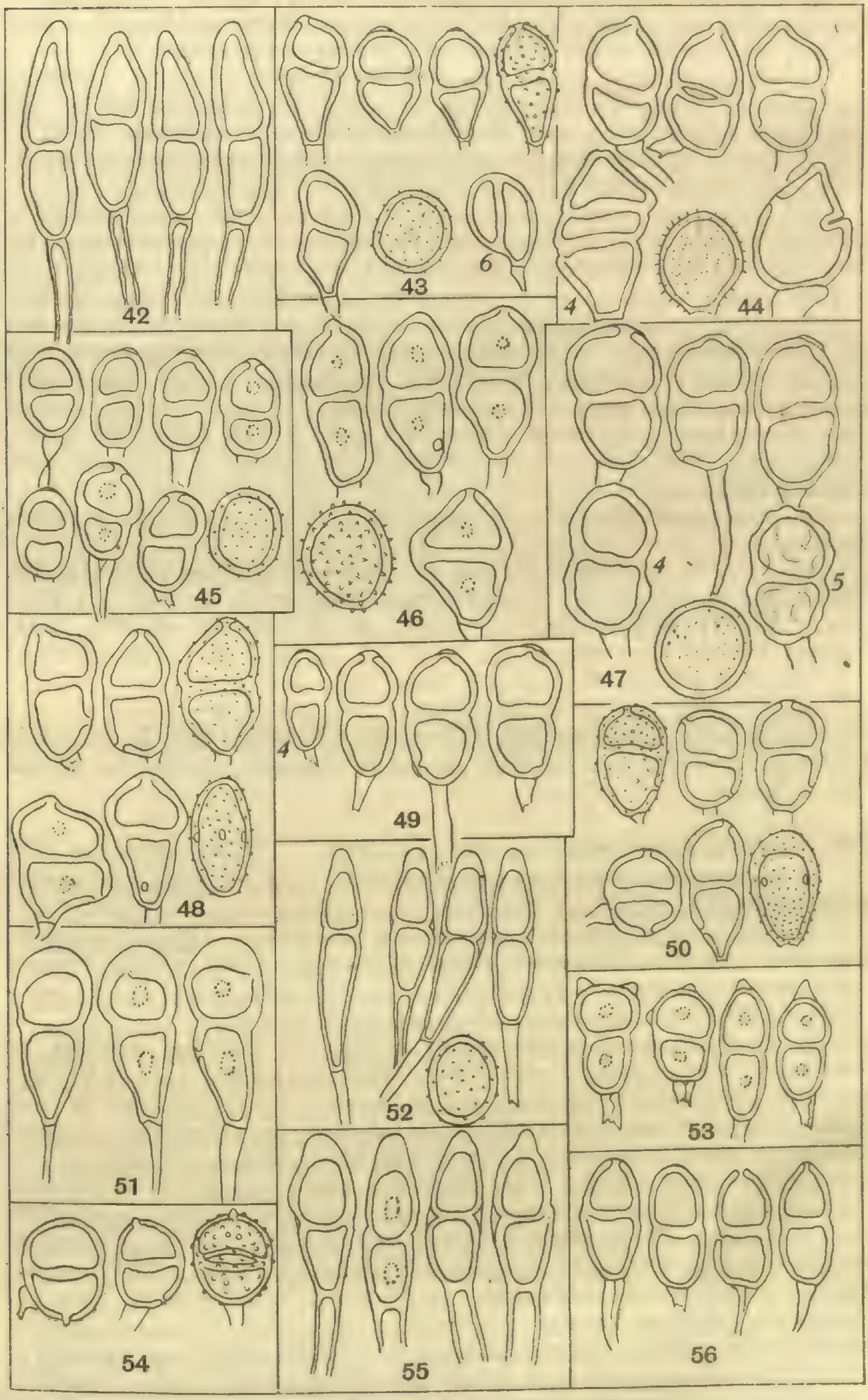
Fig. 53.—*Puccinia Dichondrae* Mont. Teleutospores from *Dichondra repens* Forst. f.

Fig. 54.—*Puccinia Menthae* Pers. Teleutospores from *Mentha Cunninghamii* Benth.

Fig. 55.—*Puccinia pedatissima* sp. nov. Teleutospores from *Ourisia macrophylla* Hook. Note persistent pedicels.

Fig. 56.—*Puccinia Coprosmae* Cke. Teleutospores from *Coprosma lucida* Forst. f.

Camera-lucida drawings by author. All × 500. *m* = mesospore.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alone showing, shortly revolute, lacerate, white. Spores subglobose to shortly elliptical, 16–19 × 12–14 mmm.; epispore finely and densely verruculose, 1·5–2 mmm. thick, hyaline, cell-contents orange-yellow.

II. Uredosori amphigenous and caulicolous, chestnut-brown, scattered, pulverulent, circular or elliptical, up to 1 mm. diam., surrounded by the ruptured epidermis. Spores subglobose, frequently elliptical, 22–27 × 18–22 mmm.; epispore coarsely and sparsely echinulate, 2–2·5 mmm. thick, cinnamon-brown, with 2–3 scattered germ-pores on one face.

III. Teleutosori amphigenous and caulicolous, dark chestnut-brown, circular, scattered, pulverulent, up to 0·5 mm. diam., surrounded by the ruptured epidermis. Spores subclavate, frequently elliptical, 25–45 × 17–26 mmm.; apex rounded, frequently somewhat acuminate, slightly thickened, up to 5 mmm., base attenuate, basal cell slightly narrower and lighter in colour than upper, cell-contents vacuolate; slightly constricted at the septum; epispore minutely but prominently warted, warts more prominent on the upper cell, chestnut-brown, 1–2 mmm. thick; pedicel deciduous, hyaline, up to 30 × 5 mmm.; germ-pore of upper cell apical, conspicuous, basal pore immediately below the septum, conspicuous, both usually papillate.

X. Mesospores uncommon, elliptical, 22–26 × 29 mmm.; apex rounded, thickened.

Host: *Viola Cunninghamii* Hook. f. On leaves, petioles, and peduncles. Herb. No. 21. I, II, III. Loburn (Otago), 300 m., *W. D. Reid!* 4 Dec., 1921. II, III. Brightwater (Canterbury), *W. H. Bryant!* 25 May, 1911. Mount Torlesse (Canterbury), *W. D. Reid!* 10 Feb., 1921. Mount Pisa; Ben Lomond (Otago), *W. D. Reid!* Mar., 1921.

Distribution: Australia; Tasmania.

The host is indigenous and widespread; it occurs also in Tasmania (Cheeseman, 1906, p. 45). This species is distinguished by the warted teleutospores.

25. **Puccinia Halorrhagidis** n. sp. (Fig. 44.) Halorrhagaceae (12).

0. Spermogones epiphyllous and caulicolous, scattered, sparse, immersed, honey-coloured.

I. Aecidia hypophyllous, scattered over leaf-surface. Peridia cupulate, margins erumpent, somewhat incurved, lacerate, tinted orange. Spores globose or subglobose, 18–22 mmm. diam.; epispore finely and closely verruculose, hyaline, 1 mmm. thick, cell-contents reddish-orange.

II. Uredosori amphigenous, chiefly epiphyllous, scattered, circular, up to 1 mm. diam., bullate, pulverulent, cinnamon-brown, surrounded and partially covered by the ruptured epidermis. Spores globose or subglobose, 20–25 mmm. diam.; epispore evenly and sparsely aculeate, 2 mmm. thick, cinnamon-brown, with 2–3 equatorial germ-pores on one face.

III. Teleutosori mixed with uredosori, amphigenous and caulicolous, bullate, scattered, or frequently circinnately arranged, circular or elliptical, up to 1·5 mm. diam., chestnut-brown, long covered. Spores elliptical or elongate-oblong, frequently irregular and distorted, 28–42 × 17–27 mmm.; apex rounded, seldom acuminate, not thickened, base rounded, lower cell usually larger than upper; constricted at the septum; epispore smooth, 1·5–2·5 mmm. thick, pale chestnut-brown; pedicel deciduous, hyaline, up to 35 × 8 mmm.; germ-pore of the upper cell usually apical, sometimes one-third way down side, conspicuous, basal pore from immediately below septum to two-thirds way down side, conspicuous, both frequently papillate.

X. Mesospores common, obovate; apex acuminate, often truncate.

Hosts :—

Halorrhagis depressa (A. Cunn.) Walp. On leaves and stems. Herb. No. 414. I, II, III. Cass (Canterbury), 600 m., *W. D. Reid! N. R. Foy!* 22 Jan., 1922.

Halorrhagis erecta (Murr.) Schindler. I, II, III. Seashore, Seatoun (Wellington), *E. H. Atkinson! G. H. C.* 10 Feb., 1921. (Type.)

Both hosts are indigenous and widespread; they occur also in Australia, and *H. erecta* extends to the island of Juan Fernandez (Cheeseman, 1906, p. 148).

The teleutospores are very irregular in shape, three- and four-celled not uncommon. Characterized by the rounded, non-thickened apex, smooth epispore, and distorted teleutospores.

26. **Puccinia pulverulenta** Greville. (Fig. 45.) Onagraceae (13).

Grev., *Fl. Edin.*, p. 432, 1824.

Uredo vagans var. *Epilobii-tetragonii* DC., *Fl. Fr.*, vol. 2, p. 228, 1805. *Aecidium Epilobii* DC., *l.c.*, p. 238. *Uredo Epilobii* DC., *Fl. Fr.*, vol. 6, p. 73, 1815. *Caeoma Epilobii* Link., in Willd., *Sp. Pl.*, vol. 6, p. 59, 1825. *Trichobasis Epilobii* Berk.: Cke., *Micr. Fungi*, p. 210, 1865. *Puccinia Gayophyti* Billings, in S. Watson's *Bot. King's Expl.*, p. 414, 1871. *P. Oenotherae* Vize, *Grev.*, vol. 5, p. 109, 1877. *Aecidium Gayophyti* Vize, *Grev.*, vol. 7, p. 12, 1878. *Puccinia Epilobii-tetragonii* Wint., in Rab., *Krypt. Fl.*, vol. 1, p. 214, 1881. *P. Boisduvaliae* Peck, *Bot. Gaz.*, vol. 7, p. 45, 1882. *P. Gayophyti* Peck, *l.c.*, p. 56. *P. Clarkiae* Peck, *Bull. Torr. Club*, vol. 11, p. 49, 1884. *P. Epilobii* Schroet., *Krypt. Fl. Schles.*, vol. 1, p. 319, 1887. *P. intermedia* Diet. et Holw.: Diet., in *Bot. Gaz.*, vol. 18, p. 254, 1893. *P. Heterantha* Ell. et Ev., *Erythea*, vol. 1, p. 204, 1893. *P. Eulobi* Diet. et Holw.: Diet., *l.c.*, p. 249. *Aecidium Clarkiae* Diet. et Holw.: Diet., in *Erythea*, vol. 2, p. 129, 1894. *Puccinia Sphaerostigmatis* Diet. et Negr., *Bot. Jahrb.*, vol. 22, p. 353, 1896. *Dicaeoma Boisduvaliae* Kuntze, *Rev. Gen.*, vol. 3, p. 468, 1898. *D. Clarkiae* Kuntze, *l.c.* *D. Gayophyti* Kuntze, *l.c.* *D. heteranthum* Kuntze, *l.c.*, p. 469. *D. intermedium* Kuntze, *l.c.* *D. Oenotherae* Kuntze, *l.c.* *Puccinia Gayophyti* Speg., *Anal. Mus. Nac. Buenos Aires*, ser. 3, vol. 1, p. 63, 1902. *P. Zauschneriae* Syd., *Mon. Ured.*, vol. 1, p. 435, 1903. *P. glabella* Holway, *N. Am. Ured.*, vol. 1, p. 76, 1907. *Dicaeoma Epilobii-tetragoni* (DC.) Arth., *N. Am. Fl.*, vol. 7, p. 394, 1920.

0. Spermogones amphigenous, scattered, associated with the aecidia, honey-coloured.

I. Aecidia amphigenous, scattered or crowded, covering entire leaf-surfaces, also stems and capsules. Peridia cupulate, up to 250 mmm. diam., margins white, revolute, lacerate. Spores polygonal, 15–26 mmm. diam.; epispore finely and densely verruculose, 1 mmm. thick, hyaline, spore-contents orange-yellow.

II. Uredosori amphigenous, cinnamon-brown, circular, up to 1 mm. diam., scattered or sometimes arranged in irregular circinnate groups, pulverulent, surrounded by the ruptured epidermis. Spores subglobose, elliptical, or obovate, 21–27 × 15–24 mmm.; epispore sparsely and somewhat coarsely echinulate, up to 3 mmm. thick, cinnamon-brown, with 2 usually papillate, equatorial germ-pores on one face.

III. Teleutosori hypophyllous, dark brown, circular, frequently circinnate, scattered, pulverulent, up to 1 mm. diam., surrounded by the ruptured epidermis. Spores elliptical, or elongate clavate, 24–34 × 16–22 mmm.; apex rounded, thickened up to 5 mmm., base rounded, frequently attenuate, basal cell somewhat narrower and lighter in colour than the upper; constricted at the septum; epispore smooth, 2·5–3 mmm. thick, cinnamon-brown, cell-contents vacuolate; pedicel hyaline, deciduous, fragile, up to

50 × 6 mmm.; germ-pore of upper cell apical, or frequently one-third way down one side, conspicuous, basal pore from one-third to two-thirds way down side, obscure.

X. Mesospores rare, subclavate, 21–27 × 13–17 mmm.; thickened and rounded at apex.

Hosts:—

Epilobium chloraefolium Hausskn. On leaves. I. Mount Peel (Canterbury), 1,400 m., *H. H. Allan!* 25 Oct., 1921.

Epilobium confertifolium Hook f. On leaves. Herb. No. 179. I. Enderby Island, *L. Cockayne!* 25 May, 1911.

Epilobium glabellum Forst. f. On leaves. Herb. No. 358. II, III. Walter Peak (Otago), 400 m., *W. D. Reid!* 27 April, 1921.

Epilobium Hectori Hausskn. On leaves. Herb. No. 179. I. Alexandra (Otago), *G. H. C.* 10 Dec., 1921. II, III. Glenorchy (Otago), 400 m., *W. D. Reid!* 11 Dec., 1921.

Epilobium melanocaulon Hook. On leaves. Herb. No. 357. II, III. Walter Peak (Otago), 440 m.; Kinloch (Otago), 1,300 m., *W. D. Reid.* April, May, 1921.

Epilobium microphyllum A. Rich. Herb. Nos. 359, 429. II, III. Greenstone River bed (Otago), *W. D. Reid!* 6 April, 1921. I, II, III. River-bed, Grantham, Hanmer (Canterbury), *W. D. Reid!* 10 Nov., 1921.

Epilobium novae-zelandiae Hausskn. On leaves. Herb. No. 356. II, III. Ben Lomond Spur; Tooth Peaks (Otago). I, II, III. Paradise (Otago), 400–1,000 m., *W. D. Reid!* Mar,. April, Dec., 1921.

Epilobium nummularifolium R. Cunn. I. South Karori (Wellington), *T. Kirk!* 7 Nov., 1883.

Epilobium tasmanicum Hausskn. Herb. No. 356. I, II, III. Mount Pisa, 1,160 m.; Macraes (Otago), *W. D. Reid!* Mar., Nov., 1921.

Epilobium sp. I, II, III. Mount Egmont (Taranaki), *E. Bruce Levy!* Feb., 1918.

Distribution: Australia; North and South America; Europe; Asia.

All the hosts are endemic: some are apparently widely distributed over both Islands; others appear to be confined to a few localities (Cheeseman, 1906, pp. 175–85).

One commonly finds all three spore-forms on the same host plant. Plants infected with the aecidial stage become somewhat distorted and paler in colour than normal.

Although this species differs somewhat in sorus characters from the European forms, I find that on comparison the teleutospores are identical.

27. Puccinia cuniculi n. sp. (Fig. 46.) Umbelliferae (14).

0. Spermogones amphigenous, associated with the aecidia, sparse, scattered, minute, honey-coloured.

I. Aecidia hypophyllous and caulicolous, closely aggregated, on leaves arranged concentrically on somewhat inflated areas, forming discoloured spots which are visible on the upper surface, on stems and petioles forming linear inflated areas up to 10 mm. long. Peridia cupulate, margins expanded, not revolute, white, deeply and irregularly laciniate. Spores subglobose to polygonal, 20–22 mmm. diam.; epispore minutely and closely verruculose, 4 mmm. thick, hyaline, cell-contents tinted pale yellow.

II. Uredosori hypophyllous, pale yellow, scattered, pulverulent, up to 0·5 mm. diam., elliptical or circular, surrounded by the ruptured epidermis. Spores obovate or elliptical, 26–30 × 19–25 mmm.; epispore moderately and somewhat coarsely echinulate, 3 mmm. thick, hyaline, cell-contents tinted yellow, with 2–4 indistinct scattered germ-pores on one face.

III. Teleutosori hypophyllous, minute, lenticular, dark chocolate-brown, pulverulent, 0·5 mm. long, long covered, finally becoming exposed by the epidermis rupturing longitudinally. Spores elliptical or subclavate, 35–45 × 21–26 mmm.; apex rounded, slightly (4 mmm.) thickened, base attenuate, frequently rounded, basal cell slightly narrower than the upper; slightly constricted at the septum; epispore smooth, 2 mmm. thick, chestnut-brown, cell-contents granular, nuclei conspicuous; pedicel persistent, hyaline, fragile, up to 50 × 5 mmm.; germ-pore of the upper cell apical, conspicuous, basal pore one-half to two-thirds below septum, conspicuous, both occasionally papillate.

Host: *Angelica Gingidium* Hook f. On leaves, stems, and petioles. Herb. Nos. 289, 364. I, II, III. Punch-bowl Falls, Arthur's Pass (Canterbury), *E. H. Atkinson!* 31 Jan., 1920. (Type.) Otira Gorge (Westland), *W. D. Reid!* 20 Nov., 1921. II, III. Greenstone Valley, 500 m.; Kinloch, 870 m.; Routeburn Valley, 700 m. (Otago); *W. D. Reid!* April, May, 1921.

The host is endemic, and occurs in both Islands (Cheeseman, 1906, p. 222). The aecidia are conspicuous and numerous; the uredo- and teleuto-sori, on account of their small size, are easily overlooked.

Aecidium Anisotomes Reich., recorded as occurring on *Anisotome geniculata* Hook. f. (= *Angelica Gingidium*), may belong to this species, but the description given does not agree with the above.

This species, although it shows a general resemblance to *Puccinia Angelicae* Fcl., differs from the latter species in the uredospores not being thickened at the apex, in the presence of aecidia, and in minor differences in the teleutospores and sori.

Characterized by the smooth epispore, and slightly or not thickened apex of the teleutospore.

28. Puccinia Hydrocotyles Cooke. (Text-fig. 47, and Plate 77, fig. 10.)

Cke., *Grev.*, vol. 9, p. 14, 1880.

Caeoma Hydrocotyles Link., in Willd., *Sp. Pl.*, vol. 6, p. 22, 1825. *Trichobasis Hydrocotyles* Cke., *Jour. Bot.*, vol. 2, p. 344, 1864.

0. Spermogones epiphyllous, associated with the aecidia, arranged in small groups, minute, honey-coloured.

I. Aecidia amphigenous and sparingly caulicolous, scattered or in small groups, sulphur-yellow. Peridia cupulate, tinted yellow, margins revolute, lacerate. Spores polygonal, 20–25 × 16–20 mmm.; epispore hyaline, 1 mmm. thick, minutely and densely verruculose, cell-contents pale yellow.

II. Uredosori amphigenous, chiefly hypophyllous, scattered, sometimes confluent, circular, minute, up to 0·25 mm. diam., pulverulent, cinnamon-brown, surrounded by the ruptured epidermis. Spores globose, subglobose to obovate, 24–32 × 20–28 mmm.; epispore cinnamon-brown, 2–2·5 mmm. thick, coarsely and sparsely echinulate, with 1 conspicuous germ-pore on one face.

III. Teleutosori amphigenous, chiefly epiphyllous, scattered, circular, 0·5–1 mm. diam., pulverulent, dark chestnut-brown, surrounded by the ruptured epidermis. Spores elliptical, 38–46 × 20–26 mmm.: apex rounded,

not or scarcely thickened, base rounded, both cells same size and colour; slightly constricted at the septum; epispore smooth or with a few coarse warts, 2 mmm. thick, chestnut-brown, cell-contents vacuolate; pedicel persistent, hyaline, fragile, up to 40 × 6 mmm.: germ-pore of upper cell apical, sometimes one-third way down side, conspicuous, basal pore from one-half to two-thirds below septum, conspicuous, both papillate.

Hosts:—

Hydrocotyle moschata Forst. f. On leaves and petioles. Herb. No. 380. II. Tiritea, Palmerston North (Wellington), *R. Waters!* 27 Jan., 1921. II, III. Walter Peak (Otago), 670 m.; Table Bay Creek (Otago), 840 m.; *W. D. Reid!* April, 1921. II, III. Aicken's, Otira River (Westland), *W. D. Reid!* 20 Nov., 1921. I, II. Sandhills, Levin (Wellington), *E. H. Atkinson! G. H. C.* 14 Sept., 1922.

Hydrocotyle novae-zelandiae DC. Herb. Nos. 360, 361. I. Burke's Pass (Canterbury), *W. D. Reid!* 18 Nov., 1919. III. Mount Pisa (Otago), 1,170 m.; Rere Lake; Walter Peak (Otago); *W. D. Reid!* Mar., April, 1921. II, III. Waimakariri River bed, Cass (Canterbury), 500 m., *W. D. Reid!* 14 Aug., 1921. II, III. Loburn (Otago), 300 m.; Dunstan Mountains (Otago), 400 m.; *W. D. Reid!* Dec., 1921.

Hydrocotyle tripartita R. Br. Herb. No. 380. II, III. Rere Lake, Wakatipu (Otago), 370 m., *W. D. Reid!* 5 Mar., 1921.

Distribution: Europe; North and South America; Natal.

All three hosts are indigenous, two being endemic; the third, *H. tripartita*, also occurs in Australia and Tasmania (Cheeseman, 1906, pp. 195–97).

The aecidia of this rust have hitherto been recorded only from South America. In New Zealand this stage is rare, and but the two collections have been made. The teleutospores are described as being smooth, and as being covered with large, isolated, depressed, and rounded warts. In the New Zealand forms all stages between smooth and warted are found; teleutospores taken from *H. triparta* are perfectly smooth, from *H. novae-zelandiae* they are occasionally slightly warted, whilst in specimens from *H. moschata* they are decidedly warted: variations occur in specimens from different plants of the same species from different localities, however, as I have specimens from *H. moschata* with perfectly smooth teleutospores. Although teleutospore material appears to be rare elsewhere, it is abundant in New Zealand.

Characterized by the smooth (or sparsely and coarsely warted) epispore, and by the fact that the apex of the teleutospore is not thickened.

29. **Puccinia kopoti** n. sp. (Fig. 48.)

0. Spermogones amphigenous, sparse, scattered, honey-coloured.

I. Aecidia hypophyllous, sparse, scattered, minute. Peridia cylindrical, standing above leaf-surface, margins erect, white, lacerate. Spores polygonal, 18–24 mmm. diam.; epispore minutely and closely verruculose, hyaline, 2 mmm. thick, cell-contents pallid orange.

II. Uredosori hypophyllous, pallid yellow, elliptical, 1·5 mm. long, scattered, pulverulent, bullate, epidermis fissuring longitudinally. Spores obovate to elliptical, 25–35 × 16–20 mmm.; epispore coarsely and sparsely echinulate, 1·5–2 mmm. thick, hyaline, cell-contents sulphur-yellow, with three scattered germ-pores on one face.

III. Teleutosori amphigenous, scattered, circular to elliptical, 0·25–0·5 mm. diam., bullate, pulverulent, chocolate-brown, long covered, finally surrounded by the ruptured epidermis. Spores elliptical or frequently subclavate, 30–40 × 18–22 mmm.; apex rounded, not or scarcely (4 mmm.) thickened, base abruptly attenuate, frequently rounded, basal cell usually narrower than upper; slightly constricted at the septum; epispore finely and closely covered with minute blunt warts, 1·5–2 mmm. thick, chestnut-brown, cell-contents vacuolate; pedicel hyaline, deciduous, delicate, up to 45 × 5 mmm.; germ-pore of upper cell apical, conspicuous, papillate, basal pore half-way down side below septum, conspicuous, papillate.

Host: *Anisotome aromatica* Hook. f. On leaves and petioles. Herb. No. 377. I, II, III. Lake Harris (Otago), 1,100 m., *W. D. Reid!* 6 May, 1921. (Type.)

This species, although close to *P. cuniculi*, is separated because of the scattered aecidia, more elliptical uredospores, and warted teleutospores.

The teleutospores are more irregular than in the former species, and more clavate in shape.

30. **Puccinia Oreomyrrhidis** n. sp. (Fig. 49.)

0. Spermogones amphigenous, scattered, minute, honey-coloured.

III. Teleutosori amphigenous, chiefly hypophyllous, and caulicolous, at first scattered, circular, minute, up to 0·5 mm. diam., and surrounded by the ruptured epidermis, becoming confluent and pulverulent until frequently the whole under-surface of the leaf becomes covered. Spores elliptical, seldom subclavate, 31–45 × 17–20 mmm.; apex rounded, slightly thickened, 3–3·5 mmm., base attenuate, basal cell slightly longer and narrower than upper; constricted at the septum; epispore minutely but distinctly punctate, 1·5–2 mmm. thick, chestnut-brown, cell-contents vacuolate; pedicel persistent, hyaline, fragile, up to 80 × 8 mmm.; germ-pore of upper cell apical, conspicuous, basal pore three-fourths way below septum, conspicuous.

X. Mesospores uncommon, obovate to clavate, somewhat truncate, 22–28 × 15–25 mmm.

Host: *Oreomyrrhis andicola* Endl. On leaves. Herb. No. 278. III. Glen Wye, Hanmer (Canterbury), *W. D. Reid!* 25 Oct., 1919. (Type.)

The host is indigenous and widespread; it occurs also in Australia, Tasmania, and South America (Cheeseman, 1906, p. 206).

The sori frequently cover the entire under-surfaces of the leaves, rendering them very conspicuous. About 1 per cent. of small spores are present in the sori; these are similar in appearance to the normal spores save only in size, which, on the average, is 31×17 mmm. (Fig. 49, No. 4.)

Characterized by the punctate epispore of the teleutospore.

31. **Puccinia Thuemeni** (Thuemen) McAlpine. (Fig. 50.)

McAlp., *Rusts Aus.*, p. 168, 1906.

Puccinia Castagnei Thuemen, *Rev. Myc.*, vol. 2, p. 86, 1880.

0. Spermogones amphigenous, in groups on minute raised spots, honey-coloured.

II. Uredosori amphigenous, circular or elliptical, up to 1·5 mm. diam., scattered or crowded, becoming confluent, pulverulent, bullate, cinnamon-brown, surrounded by the ruptured epidermis. Spores obovate or elliptical, 25–38 × 19–22 mmm.; apex thickened, up to 8 mmm.; epispore golden-brown, coarsely and sparsely verruculose, 2–2·5 mmm. thick, with 3–4 equatorial germ-pores on one face.

III. Teleutosori similar to the uredosori but dark chestnut-brown. Spores subclavate or broadly elliptical, 29–40 × 16–22 mmm.; apex rounded, not thickened, base rounded, seldom subattenuate, both cells usually same size and colour, lower sometimes slightly narrower; slightly or not constricted at the septum; epispore golden-brown, finely and sparsely verrucose, 1·5–2 mmm. thick; pedicel deciduous, hyaline, short, up to 35 × 5 mmm.; germ-pore of the upper cell apical, conspicuous, papillate, basal pore two-thirds below the septum, conspicuous, papillate.

Host: *Apium prostratum* (DC.) Lab. On leaves and stems. Herb. No. 313. II. Seashore, Seatoun (Wellington), *G. H. C.* 10 Feb., 1921.

Distribution: Australia; Tasmania.

The host is indigenous, and occurs also in Australia, Tasmania, Antarctic America, and South Africa (Cheeseman, 1906, p. 205).

Characterized by the non-thickened apex and warted epispore of the teleutospores, and the thickened apex of the uredospores.

I am indebted to Mr. C. C. Brittlebank for material of this rust for comparative purposes.

32. **Puccinia Cockaynei** n. sp. (Fig. 51.) Gentianaceae (15).

0. Spermogones amphigenous, seated on yellow spots, mixed with or surrounding the uredosori, immersed, honey-coloured.

II. Uredosori amphigenous, chestnut-brown, circular to elliptical, minute, up to 1 mm. diam., scattered, pulverulent, bullate, surrounded by the ruptured epidermis. Spores subglobose, elliptical, or commonly obovate, 20–32 × 17–26 mmm.; epispore finely and sparsely echinulate, 2 mmm. thick, cinnamon-brown, with one conspicuous germ-pore on one face.

III. Teleutosori amphigenous, chiefly hypophyllous, chocolate-brown, circular to elliptical, up to 1 mm. diam., scattered, pulverulent, surrounded by the ruptured epidermis. Spores clavate, seldom elliptical, 30–38 × 18–24 mmm.; apex bluntly rounded, frequently bluntly acuminate, thickened up to 6 mmm., base attenuate, seldom rounded, basal cell narrower and lighter in colour than the upper; slightly constricted at the septum; epispore chestnut-brown, smooth, 1·5–2 mmm. thick, cell-contents vacuolate, nuclei evident; pedicel deciduous, hyaline, fragile, up to 50 × 8 mmm.; germ-pore of the upper cell apical, conspicuous, basal pore immediately below the septum, conspicuous, sometimes papillate.

X. Mesospores rare, subglobose or elliptical, 18–22 × 16–20 mmm.

Hosts:—

Gentiana corymbifera T. Kirk. On leaves. Herb. Nos. 186, 349, 374. II, III. Queenstown (Otago), *E. H. Atkinson!* 22 Jan., 1920. (Type.) II, III. Mount Peel (Canterbury), 600 m., *H. H. Allan!* 6 Mar., 1921. Ben Lomond Spur; Mount Cardrona; Mount Dick; Kinloch (Otago), 400–1,200 m., *W. D. Reid!* Mar., April, May, 1921. II. Mount Isobel, Hanmer (Canterbury), 1,170 m., *W. D. Reid!* 4 Nov., 1921.

Gentiana Grisebachii Hook. f. On leaves. II. Makarora Flat (Otago), *W. D. Reid!* 26 Mar., 1921.

Both hosts are endemic, *G. corymbifera* being confined to the South Island (Cheeseman, 1906, pp. 448–49). The teleutospores are regular in shape, and are remarkably uniform on the different collections from different localities.

This species differs from *P. tararua* G. H. Cunn. in that the latter rust possesses fusiform teleutospores. Although showing a general resemblance to *P. Gentianae* Link., this species differs in the thickened, non-apiculated apex and attenuated base of the teleutospore.

I have named this rust in honour of A. H. Cockayne, Government Biologist, whose constant advice and assistance have made this work possible.

33. Puccinia tararua n. sp. (Fig. 52.)

0. Spermogones amphigenous, sparse, scattered, immersed, honey-coloured.

II. Uredosori amphigenous and caulicolous, scattered or aggregated into irregular groups, up to 2 mm. diam., circular, pulverulent, cinnamon-brown, surrounded by the ruptured epidermis. Spores obovate, less commonly subglobose, 20–30 × 18–23 mmm. ; epispore coarsely and sparsely echinulate, 4 mmm. thick, pale yellow, with one prominent germ-pore on the one face.

III. Teleutosori amphigenous and caulicolous, scattered, circular, up to 1 mm. diam., chestnut-brown, pulvinate, compact, surrounded by the ruptured epidermis. Spores fusiform, 50–70 × 10–15 mmm. ; apex bluntly acuminate or rounded, thickened up to 10 mmm., base attenuate, tapering gradually into pedicel, both cells same size and colour ; slightly or not constricted at the septum ; epispore smooth, 1 mmm. thick, tinted pallid brown, or ochraceous, cell-contents vacuolate ; pedicel persistent, hyaline, stout, up to 50 × 10 mmm., continuous with spore ; germ-pore of upper cell apical, obscure, basal pore immediately below septum, obscure.

Host : *Gentiana patula* Cheesem. On leaves and stems. Herb. No. 379. II, III. Table-top, Mount Hector (Wellington), 1,170 m., *E. H. Atkinson !* 6 Feb., 1921. (Type.)

The host is endemic, and in the North Island is confined to the Tararua Range ; in the South Island it appears to be common in mountainous country (Cheeseman, 1906, p. 452).

This species is characterized by the thin-walled fusiform teleutospores.

34. Puccinia Dichondrae Montagne. (Fig. 53.) Convolvulaceae (16).

Mont., in C. Gay's *Fl. Chile*, vol. 8, p. 46, 1852.

Puccinia Dichondrae Berk., *Linn. Jour. Bot.*, vol. 13, p. 173, 1872. *P. Berkeleyana* De Toni, in *Sacc. Syll.*, vol. 7, p. 717, 1888. *P. munita* Ludw., *Zeits. f. Pflanzenkr.*, vol. 2, p. 133, 1892.

0. Unknown.

III. Teleutosori amphigenous, chiefly hypophyllous, chocolate-brown, circular, minute, up to 200 mmm. diam., pulverulent, at first scattered, becoming confluent until finally the whole leaf-surface becomes covered. Spores elliptical to subclavate, 30–50 × 15–25 mmm. ; apex rounded, sometimes bluntly acuminate, thickened up to 5 mmm., or not thickened, usually with a coloured apiculus, sometimes two, base subattenuate, frequently rounded, basal cell somewhat narrower than the upper ; constricted at the septum ; epispore smooth, 1–1·5 mmm. thick, golden-brown, cell-contents granular, nuclei conspicuous ; pedicel persistent, hyaline, sometimes tinted, fragile, up to 46 × 5 mmm. ; germ-pore of upper cell apical, obscure, basal pore immediately below septum, obscure, both papillate.

X. Mesospores uncommon, elliptical, 21–30 × 15–22 mmm. ; apex rounded and apiculate.

Hosts :—

Dichondra repens Forst. f. On leaves. Herb. No. 74. III. Ashburton (Canterbury), *H. H. Allan!* 20 Nov., 1919.

Dichondra brevifolia Buch. On leaves. III. Macraes (Otago), 600 m., *W. D. Reid!* 29 Nov., 1921.

Distribution : Australia ; Tasmania ; North and South America.

The hosts are indigenous, one being endemic, the other, *D. repens*, occurring also in the tropical and subtropical districts of both hemispheres (Cheeseman, 1906, p. 478). The marked heteromorphy mentioned by McAlpine (1906, p. 143) as occurring in the Australian specimens is not present in the New Zealand forms. An occasional vertical septum is seen, but one-celled and more than two-celled forms are rare. The most variable feature appears to be the position of the apiculus, which may be apical, or anywhere on the side. Frequently two or more are present on the same spore. I find them to be coloured ; McAlpine states that they are hyaline.

35. **Puccinia Menthae** Persoon. (Fig. 54.) Labiatae (17).

Pers., *Syn. Fungi*, p. 227, 1801.

Uredo Menthae Pers., *l.c.*, p. 220. *Aecidium Menthae* Sow., *Engl. Fungi*, pl. 398, fig. 3, 1803. *Uredo Calaminthae* Strauss., *Ann. Wettst. Ges.*, vol. 2, p. 95, 1810. *Puccinia Clinopodii* DC., *Fl. Fr.*, vol. 6, p. 67, 1815. *Uredo Labiatarum* DC., *l.c.*, p. 72. *U. Menthastri* Link., *Ges. Nat. Fruende Berlin Mag.*, vol. 7, p. 27, 1815. *Dicaeoma Menthae* S. F. Gray, *Nat. Arr. Brit. Pl.*, vol. 1, p. 542, 1821. *Uredo Clinopodii* Schw., *Schr. Nat. Ges. Leipsig*, vol. 1, p. 70, 1822. *Caeoma Labiatarum* Schlecht., *Fl. Berol.*, vol. 2, p. 128, 1824. *Puccinia Labiatarum* Schlecht., *l.c.*, p. 133. *Caeoma menthatum* Link., in Willd., *Sp. Pl.*, vol. 6, p. 47, 1825. *Puccinia Pycnanthemi* Schw., *Trans. Am. Phil. Soc.*, ser. 2, vol. 4, p. 295, 1832. *Uredo Satureiae* Cast., *Cat. Pl. Marseille*, Suppl. 89, 1851. *Aecidium ovoideo-aurantium* Bon., *Coniom.*, 45, 1860. *Puccinia Calaminthae* Fcl., *Symb. Myc.*, p. 56, 1869. *P. Menthae americana* Burrill, *Bull. Ill. Lab. Nat. Hist.*, vol. 2, p. 191, 1885. *Dicaeoma Pycnanthemi* Kuntze, *Rev. Gen.*, vol. 3, p. 470, 1898.

0. Spermogones amphigenous, in small groups, honey-coloured.

I. Aecidia amphigenous, chiefly hypophyllous, and caulicolous, on leaves seated on inflated orange or purplish areas, gregarious, on stems elliptical, yellow. Peridia cupulate, 0·25 mm. diam., margins white, erect, or somewhat incurved, lacerate. Spores 22–36 × 16–26 mmm., globose or elliptical ; epispore pallid yellow, 1·5–2 mmm. thick, densely and coarsely verruculose, cell-contents orange-yellow.

II. Uredosori hypophyllous, on yellow spots, scattered, circular, minute, 0·25–0·5 mm. diam., cinnamon-brown, pulverulent, surrounded by the ruptured epidermis. Spores globose to obovate, 20–28 × 16–20 mmm. ; epispore sparsely and coarsely echinulate, pallid brown, 1·5 mmm. thick, with 3 equatorial germ-pores on one face.

III. Teleutosori hypophyllous, scattered, minute, up to 0·5 mm. diam., chocolate-brown, pulverulent, surrounded by the ruptured epidermis. Spores broadly elliptical, 22–32 × 18–23 mmm. ; apex rounded, not thickened, base rounded, both cells same size and colour ; slightly or not constricted at the septum ; epispore somewhat sparsely and minutely verrucose, 1–2 mmm. thick, chestnut-brown ; pedicel persistent, hyaline, fragile, up to 40 × 5 mmm. ; germ-pore of upper cell apical, conspicuous, basal pore varying in position between septum and pedicel, conspicuous, papillate.

Host : *Mentha Cunninghamii* Benth. On leaves. Herb. No. 348. II, III. Table Bay (Otago), 835 m., *W. D. Reid!* 29 April, 1921.

Distribution: Australia; North America; Europe; Asia; Africa.

The aecidial stage has not been collected in New Zealand. The host is endemic and widely distributed (Cheeseman, 1906, p. 568).

I am indebted to Dr. Grove for specimens of this rust for comparative purposes. The mycelium of the aecidia is perennial. There are minor differences between our form and the European; these are not as great, however, as the differences between European and American specimens that I have in the herbarium.

36. **Puccinia pedatissima** n. sp. (Fig. 55.) Scrophulariaceae (18).

0. Unknown.

III. Teleutosori hypophyllous, minute, circular, 0·1–0·25 mm. diam., closely aggregated in minute scattered circular groups up to 2 mm. diam., compact, pulvinate, naked, ochraceous. Spores elliptical or shortly fusoid, 40–52 × 14–18 mmm.; apex bluntly acuminate, thickened up to 8 mmm., base attenuate, both cells same size or basal cell somewhat narrower, cell-contents granular, nuclei conspicuous; slightly or not constricted at the septum; epispore smooth, 1–1·5 mmm. thick, tinted brown; pedicel persistent, hyaline, up to 40 × 6 mmm., continuous with the spore; germ-pore of upper cell apical, obscure, basal pore immediately beneath the septum, obscure.

X. Mesospores uncommon, 25–30 × 12–16 mmm.; apex acuminate and thickened.

Host: *Ourisia macrophylla* Hook. On leaves, veins, and petioles. Herb. No. 494. III. Mount Egmont (Taranaki), 1,200 m., *W. D. Reid! N. R. Foy!* 2 Jan., 1922. (Type.)

The host is endemic and confined to the mountain regions of both Islands (Cheeseman, 1906, p. 549). The spores germinate immediately on reaching maturity. This species is closely related to *Puccinia apus* Diet. et Neg., but differs chiefly in the hypophyllous sori, larger teleutospores, and *persistent* pedicels.

37. **Puccinia Coprosmae** Cooke. (Fig. 56.) Rubiaceae (19).

Cke., *Grev.*, vol. 19, p. 2, 1890.

Puccinia Coprosmatis Morrison, *Vic. Nat.*, vol. 11, p. 90, 1894.

0. Unknown.

III. Teleutosori hypophyllous, closely crowded on discoloured spots which may reach a diam. of 5 mm., circular or elliptical, pulvinate, compact, at first covered, finally becoming exposed by the epidermis falling away in patches from the surface, but remaining surrounding the sori at the base. Spores elongate-oblong or clavate, 36–50 × 16–21 mmm.; apex bluntly acuminate, rounded, thickened up to 8 mmm., base rounded, frequently attenuate, basal cell same length as upper but somewhat narrower and lighter in colour; constricted at the septum; epispore smooth, tinted brown, 2 mmm. thick, cell-contents vacuolate; pedicel persistent, tinted, up to 100 × 8 mmm., continuous with the spore; germ-pore of the upper cell apical, conspicuous, basal pore immediately beneath the septum, conspicuous.

X. Mesospores common, obovate or elliptical, 21–38 × 14–20 mmm.; apex acuminate.

Hosts :—

Coprosma grandifolia Hook. f. On leaves. Herb. Nos. 6, 320. III. Botanical Gardens, Palmerston North (Wellington), *R. Waters!* 27 Jan., 1921.

Coprosma lucida Forst. f. On leaves. III. Stewart Island, *T. Kirk!* 1888. (Cotype.) York Bay (Wellington), *E. H. Atkinson!* 13 Feb., 1921. Ben Lomond Spur; Makarora (Otago), *W. D. Reid!* Mar., 1921.

Coprosma robusta Raoul. On leaves. III. Lake Papaetonga, Weraroa (Wellington), *G. H. C.* 31 Dec., 1919. Otira Gorge (Canterbury), *E. H. Atkinson!* 30 Jan., 1920.

Distribution: Australia; Tasmania.

All three hosts are endemic and widespread (Cheeseman, 1906 pp. 246–48). On *C. robusta* this fungus forms large brown spots which are very conspicuous; on *C. lucida* these spots are much less common, and are frequently absent.

Cooke's description is so fragmentary that it would be wellnigh impossible to determine any species from it; fortunately I have the cotype material from which the species was named, and the above description is drawn up from this. This is one of our commonest indigenous rusts.

38. **Puccinia aucta** Berkeley and F. v. Mueller. (Fig. 57.)
Campanulaceae (20).

Berk. et F. v. M., *Linn. Jour.*, vol. 13, p. 173, 1872.

0. Unknown.

III. Teleutosori hypophyllous, frequently covering the entire undersurface of the leaf, cinnamon-brown, circular, scattered, often confluent, pulvinate, compact, 0·5 mm. diam., surrounded by the ruptured epidermis. Spores subclavate, 35–70 × 15–26 mmm.; apex rounded, truncate, or frequently bluntly acuminate, thickened up to 11 mmm., base attenuate, basal cell narrower and longer than the upper, frequently cylindrical, sometimes lighter in colour; constricted at the septum, often markedly; epispore smooth, 1–1·5 mmm. thick, tinted pale brown, cell-contents granular, nuclei conspicuous; pedicel persistent, tinted, short, stout, up to 35 × 12 mmm.; germ-pore of upper cell apical, conspicuous, basal pore immediately below the septum, obscure, seldom papillate.

Host: *Lobelia anceps* Linn. f. On leaves and stems. Herb. No. 312. III. Seashore, Pencarrow (Wellington), *E. H. Atkinson!* 10 Feb., 1921. Seashore, Seatoun (Wellington), *G. H. C.* 10 Feb., 1921.

Distribution: South Australia.

The host is indigenous and widespread; it occurs also in Australia (Cheeseman, 1906, p. 400). Although McAlpine (1906, p. 148) describes in connection with this species an aecidium occurring on the same host, I consider the two forms to belong to different species, because in New Zealand, where the teleutospores are common, no aecidia are found, whereas in Australia but one (the type) collection has been made of the teleutospores, where an aecidium appears to be common on various species of *Lobelia* and on *Pratia* spp., a closely related genus. McAlpine states that he has not found the two forms on the same host at the same time, but groups them together as a matter of convenience until such time as their relationships are proven.

39. Puccinia Allanii n. sp. (Fig. 58.) Compositae (21).

0. Spermogones amphigenous, sparse, a few mixed with the aecidia, honey-coloured.

I. Aecidia amphigenous, closely aggregated on discoloured spots, in more or less circular groups, yellow. Peridia cupulate, margins expanded, but not revolute, lacerate, white. Spores polygonal, frequently subglobose, 12–18 mm. diam.; epispore verruculose, 1 mmm. thick, hyaline, cell-contents orange.

III. Teleutosori hypophyllous, associated with the aecidia, minute, 0·25–0·5 mm. diam., circular, pulvinate, compact, dark chestnut-brown, surrounded by the ruptured epidermis. Spores elliptical, commonly sub-clavate, 35–55 × 18–26 mmm.; apex rounded, often bluntly acuminate, thickened up to 10 mmm., darker in colour, base attenuate, upper cell darker in colour and somewhat broader than lower; constricted at the septum; epispore smooth, chestnut-brown, 3 mmm. thick in upper cell, 2 mmm. in lower; pedicel persistent, tinted, up to 50 × 10 mmm.; germ-pore of upper cell apical, conspicuous, basal pore immediately below septum, obscure.

Host: *Senecio lagopus* Raoul. On leaves. Herb. No. 425. I, III. Mount Herbert, Banks Peninsula (Canterbury), *H. H. Allan!* 5 Feb., 1921. (Type.)

The host is endemic and fairly widely distributed (Cheeseman, 1906, p. 370). This species is named in honour of Dr. H. H. Allan, of Feilding, who has forwarded numerous specimens of rusts he has collected during his many botanical expeditions in the Canterbury mountains.

Distinguished by the thickened, capped apex, thick epispore, and conspicuous apical germ-pore of the teleutospores. The sorus characters serve to distinguish it from *P. pounamu* and others which show a general resemblance to this species.

40. Puccinia Atkinsonii n. sp. (Fig. 59.)

0. Spermogones hypophyllous, associated with the aecidia, minute, immersed, honey-brown.

I. Aecidia hypophyllous, aggregated in large closely-packed groups on distorted spots which are visible on the upper surface as dark-brown dead areas, up to 25 mm. in length, circular or linear, in mass bright orange. Peridia embedded, margins alone showing, depressed-globose, up to 800 mmm. wide by 450 mmm. high, margin entire, upright. Spores subglobose, elliptical, frequently lacrimiform, with an elongated hyaline apiculus, 25–35 × 15–22 mmm.; epispore densely and minutely verrucose, 2 mmm. thick, hyaline, cell-contents reddish-orange, granular.

III. Teleutosori hypophyllous, on minute dark-brown spots which are visible on the upper surface, dark chocolate-brown, almost black, circular, up to 0·5 mm. diam., scattered at first, covered by the dense tomentum of the leaf, becoming erumpent and pulverulent. Spores broadly elliptical, 40–65 × 20–35 mmm.; apex retuse, less frequently papillate, thickened up to 7 mmm. or not thickened, base rounded, seldom attenuate, both cells same size and colour; slightly constricted at the septum; epispore smooth, 2·5–3 mmm. thick, pale chestnut-brown, cell-contents vacuolate; pedicel deciduous, hyaline, up to 45 × 8 mmm.; germ-pore of the upper cell apical or more frequently varying in position between apex and septum, basal pore usually one-third below septum, both markedly conspicuous and at first papillate, later the papilla collapses and an indentation in the epispore over the germ-pore is formed.

X. Mesopores uncommon, subglobose, elliptical to obovate, 35–55 × 38–45 mmm.

Host: *Olearia excorticata* Buch. On leaves. Herb. No. 308. I, III. Table-top, Mount Hector (Wellington), 1,170 m., *E. H. Atkinson!* 6 Feb., 1921. (Type.)

The host is endemic and rather uncommon, being confined to the Tararua Range in the North Island, and to the subalpine scrub of the Westland district in the South Island (Cheeseman, 1906, p. 287).

The aecidia form bright-orange patches up to 25 mm. long on the leaves; they are much more conspicuous than the teleutosori, which are easily overlooked. Young teleutospores have orange contents, and the germ-pores are strongly papillate; after a time the colour changes to light brown, and the papilla collapses or becomes inverted, forming a minute conical indentation in the epispore above the germ-pore; this peculiarity is more noticeable over the apical, but is quite common above the basal pore.

This rust is named in honour of Esmond H. Atkinson, of the Biological Laboratory, who has collected many of the specimens in my herbarium. He has, moreover, verified the host plants—no mean undertaking, considering the fragmentary nature of much of the material, as in many instances leaves alone are collected and forwarded.

Characterized by the thick-walled epispore of the teleutospore, and the peculiar thickened, retuse apex.

41. Puccinia Cardui-pycnocephali Sydow. (Fig. 60.)

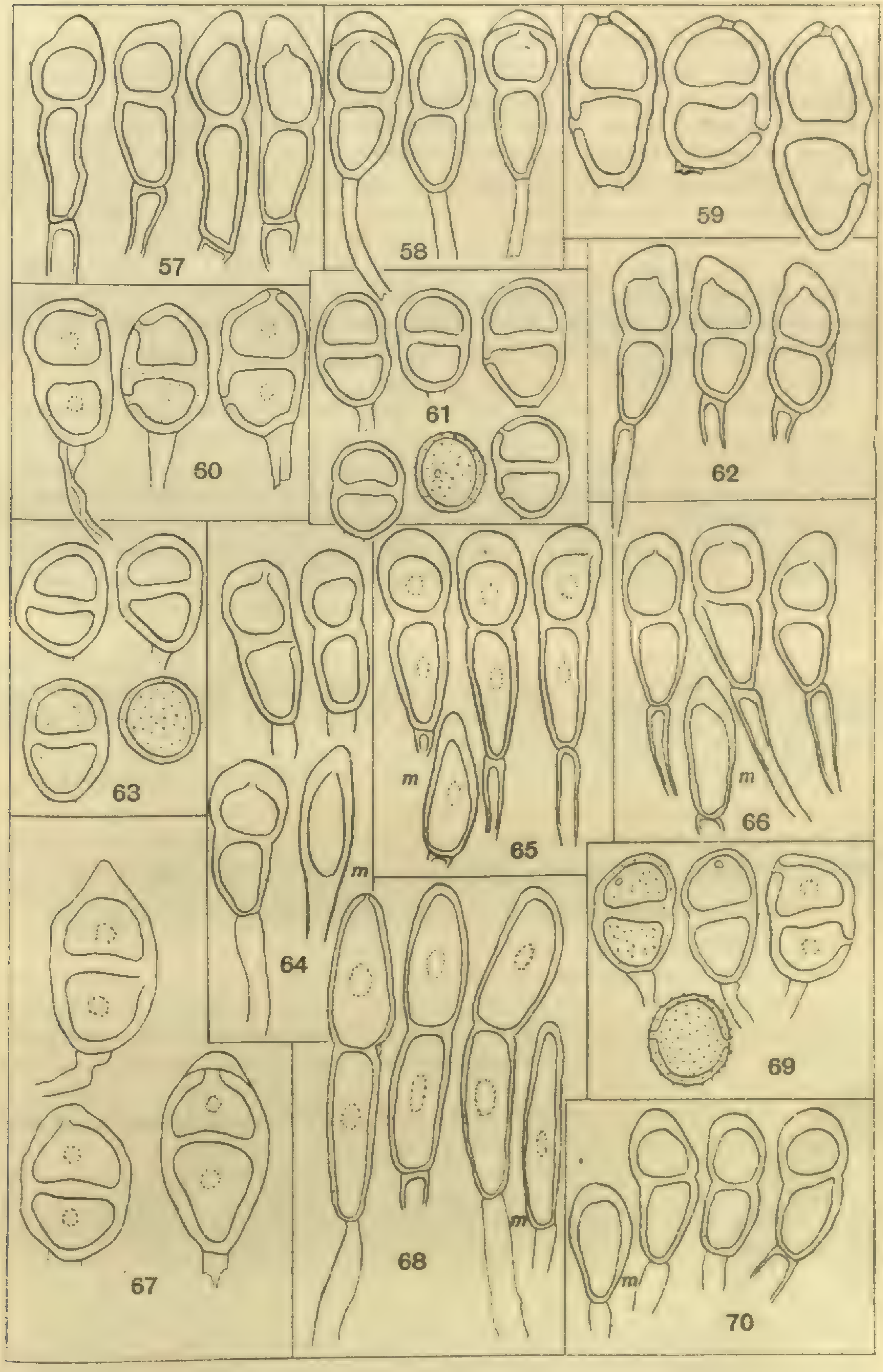
Syd., *Mon. Ured.*, vol. 1, p. 34, 1902.

Puccinia galatica **Syd., *Mon. Ured.*, vol. 1, p. 34, 1902.**

0, I. Unknown.

II. Uredosori amphigenous, chestnut-brown, circular, scattered, pulverulent, 0·5–1 mm. diam., surrounded by the ruptured epidermis. Spores globose, subglobose, to ovate, 27–33 × 22–28 mmm.; epispore evenly and closely echinulate, 2–2·5 mmm. thick, thickened to 4 mmm. above insertion of pedicel, with 2–3 scattered, papillate germ-pores on one face.

Fig. 57.—*Puccinia aucta* Berk. et F. v. M. Teleutospores from *Lobelia anceps* Linn. f.
Fig. 58.—*Puccinia Allanii* sp. nov. Teleutospores from *Senecio lagopus* Raoul.
Fig. 59.—*Puccinia Atkinsonii* sp. nov. Teleutospores from *Olearia excorticata* Buch.
Fig. 60.—*Puccinia Cardui-pycnocephali* Syd. Teleutospores from *Carduus pycnocephalus* L.
Fig. 61.—*Puccinia Cichorii* Bell. Uredo- and teleuto-spores from *Cichorium Intybus* L.
Fig. 62.—*Puccinia Cinerariae* McAlp. Teleutospores from *Cineraria* sp. cult.
Fig. 63.—*Puccinia Cyani* Pass. Uredo- and teleuto-spores from *Centaurea Cyanus* L.
Fig. 64.—*Puccinia distincta* McAlp. Teleutospores from *Bellis perennis* L.
Fig. 65.—*Puccinia egmontensis* sp. nov. Teleutospores from *Celmisia glandulosa* Hook. f.
Fig. 66.—*Puccinia Erechtitis* McAlp. Teleutospores from *Erechtites prenanthoides* DC.
Fig. 67.—*Puccinia fodiens* sp. nov. Teleutospores from *Celmisia rigida* (T. Kirk) Cockayne.
Fig. 68.—*Puccinia hectorensis* sp. nov. Teleutospores from *Senecio Bidwillii* Hook. f. Reduced scale. × 325.
Fig. 69.—*Puccinia Hypochoeridis* Oud. Uredo- and teleuto-spores from *Hypochoeris glabra* L.
Fig. 70.—*Puccinia Lagenophorae* Cke. Teleutospores from *Lagenophora Barkeri* T. Kirk.
Camera-lucida drawings by author. All × 500 except fig. 68. *m* = mesopores.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III. Teleutosori amphigenous and caulicolous, chocolate-brown, circular, scattered, pulvinate, compact, 0·5–1 mm. diam., at first covered, soon naked and embedded in tomentum of leaf. Spores elliptical, oblong, sometimes subclavate, 30–48 × 20–28 mmm.; apex rounded, rarely truncate, not thickened, base rounded, basal cell same size and colour as upper, seldom slightly narrower; slightly constricted at the septum; epispore verruculose, 2·5–3 mmm. thick, cell-contents granular, nuclei prominent; pedicel persistent, fragile, hyaline, up to 60 × 7 mmm.; germ-pore of the upper cell apical or one-quarter way down one side, conspicuous, basal pore one-quarter way below septum, conspicuous, both occasionally papillate.

Host: *Carduus pycnocephalus* L. On leaves and stems. Herb. Nos. 270, 316, 357. III. Fitzroy Bay (Wellington), *E. H. Atkinson!* 17 Mar., 1920. II, III. Cluny, Turakina (Wellington), *G. H. C.* 2 Jan., 1921. III. Dunstan Mountains (Otago), 500 m., *A. H. Cockayne!* 8 Feb., 1921. II. Walter Peak (Otago), 440 m., *W. D. Reid!* 27 April, 1921.

Distribution: Britain; Italy; Asia Minor.

The host is a thistle common in drier localities throughout New Zealand; it has been introduced from Europe, probably in grass-seed. The rust is common wherever the host occurs; it appears to check seed-development in the host, as one commonly finds sterile flower-heads in infected plants.

I am indebted to Dr. W. B. Grove for the determination of this species from specimens forwarded; I was under the impression that it was *P. galatica* Syd., but Dr. Grove informs me that in a later publication Sydow admitted that the latter name was a synonym. Unfortunately I have been unable to obtain access to Sydow's *Monograph.*

In his description (of *P. galatica*) Sydow states that the teleutospore is finely punctate. Grove (1913, p. 142) states that the teleutospore is smooth. I find that when the spores are mounted dry and examined they are seen to be distinctly verruculose.

Characterized by the thick, verruculose epispore of the teleutospore.

42. Puccinia Chrysanthemi Roze.

Roze, *Bull. Soc. Myc. France*, vol. 17, p. 92, 1900.

Puccinia Chrysanthemi-chinensis P. Henn., *Hedw. Beibl.*, vol. 40, p. 26, 1901.

0, I. Unknown.

II. Uredosori amphigenous, chiefly hypophyllous, sometimes caulicolous, on brown dead spots which are visible on the opposite surface of the leaf, cinnamon-brown, circular, seldom elliptical, scattered, frequently confluent, sometimes circinnate, pulverulent, up to 2 mm. diam., surrounded by the ruptured epidermis. Spores elliptical or obovate, seldom subglobose, 20–34 × 20–25 mmm.; epispore moderately echinulate, 2–2·5 mmm. thick, cinnamon-brown, with 3 equatorial germ-pores on one face.

III. Teleutosori amphigenous, chiefly hypophyllous, chocolate-brown, circular, scattered, or confluent, frequently circinnate, pulvinate, compact, soon naked. Spores elliptical, clavate, or often pyriform, 38–55 × 20–26 mmm.; apex rounded, rarely truncate, thickened up to 7 mmm., base rounded, seldom attenuate, basal cell slightly narrower and lighter in colour than upper; slightly constricted at the septum; epispore finely but distinctly punctate, 1·5–2 mmm. thick, chestnut-brown, cell-contents coarsely vacuolate; pedicel persistent, hyaline, stout, up to 80 × 9 mmm.; germ-pore of upper cell apical, obscure, basal pore immediately below the septum, obscure.

X. Mesospores rare, elliptical to clavate, 28–46 × 22–25 mmm.; apex thickened.

Host: *Chrysanthemum indicum* L. On leaves and stems. Herb. No. 73. II. Palmerston North (Wellington), *G. H. C.* 4 June, 1919.

Distribution: Australia; Japan; Europe; North America.

The uredospore stage alone has been collected in New Zealand. The above description of the teleutospores was drawn up from material kindly supplied by Mrs. F. W. Patterson. The teleutospores appear to be rare everywhere, with the exception of Japan, where they are stated to be abundant.

Characterized by the thick apex and punctate epispore of the teleutospore.

43. Puccinia Cichorii Bellynck. (Fig. 61.)

Bell., in Kickx *Fl. Crypt. Fland.*, vol. 2, p. 65, 1867.

Puccinia Hieracii Mart., *Fl. Mosq.*, p. 226, 1812. *Uredo Cichorii* DC., *Fl. Fr.*, vol. 6, p. 74, 1815.

0, I. Unknown.

II. Uredosori amphigenous and caulicolous, cinnamon-brown, circular, scattered, seldom confluent, pulverulent, up to 0·5 mm. diam., surrounded by the ruptured epidermis. Spores subglobose, elliptical, or often obovate, 22–30 × 20–26 mmm.; epispore delicately and moderately echinulate, 2–2·5 mmm. thick, yellowish-brown, with 1–2 germ-pores on one face.

III. Teleutosori amphigenous and caulicolous, scattered, chocolate-brown, circular, pulvinate, compact, up to 0·5 mm. diam., surrounded by the ruptured epidermis. Spores elliptical, frequently obovate, 27–38 × 19–24 mmm.; apex rounded, not thickened, base rounded, seldom attenuate, both cells same size and colour; slightly or not constricted at the septum; epispore minutely verruculose, 2 mmm. thick, chestnut-brown, cell-contents granular; pedicel deciduous, hyaline, fragile, up to 45 × 7 mmm.; germ-pore of the upper cell one-third to two-thirds down one side, conspicuous, basal pore one-third way below septum, conspicuous.

Host: *Cichorium Intybus* L. On leaves and stems. Herb. No. 180. II, III. Lincoln (Canterbury), *T. Kirk!* 19 Nov., 1881.

Distribution: Australia; Europe.

The host, a native of Europe and Asia, has become more or less naturalized throughout the warmer parts of New Zealand. The epispore of the teleutospore is seen to be minutely verruculose when the spores are mounted dry and examined. Characterized by the verruculose epispore and non-thickened apex of the teleutospore.

44. Puccinia Cinerariae McAlpine. (Fig. 62.)

McAlp., *Rusts Aus.*, p. 155, 1906.

0. Unknown.

I. Aecidia amphigenous, compacted in groups on light-green spots, 5 mm. in diam., which are swollen on the under side and depressed on the upper, and on veins where they cause linear distortions 10 mm. or more in length, orange-yellow. Peridia cupulate, slightly projecting above the leaf-surface, 250 mmm. diam., margins white, revolute, deeply and irregularly laciniate. Spores subglobose to polygonal, 14–17 × 10–14 mmm.; epispore closely and minutely verruculose, hyaline, 1 mmm. thick, cell-contents bright orange.

III. Teleutosori amphigenous, intermixed with aecidia, chocolate-brown, circular, scattered, pulvinate, compact, minute, 0·25 mm. diam., surrounded by the ruptured epidermis. Spores clavate, 38–56 × 18–24 mmm.; apex bluntly acuminate, truncate, or rounded, thickened up to 10 mmm., darker in colour, base attenuate, basal cell longer, narrower, and lighter in colour than upper; slightly constricted at the septum; epispore smooth, 2 mmm. thick in upper cell, 1·5 mmm. in lower, chestnut-brown, cell-contents vacuolate; pedicel persistent, tinted, stout, up to 45 × 7 mmm.; germ-pore of upper cell apical, conspicuous, basal pore immediately below septum, obscure.

X. Mesospores rare, elliptical or obovate, 22–34 × 12–22 mmm.; apex bluntly rounded, or truncate, thickened.

Host: *Cineraria* sp. cult. On leaves. Herb. No. 305. I, III. High School grounds, Palmerston North (Wellington), *R. Waters!* 27 Jan., 1921.

Distribution: Australia.

The host is one of the varieties of cultivated *Cineraria*. The aecidia form conspicuous inflated areas on the leaves; the teleutosori are rare, and difficult to find. Characterized by the clavate teleutospores, which are thickened at the apex, and have smooth epispores.

45. Puccinia Cyani Passerini. (Fig. 63.)

Pass., in Rab. *Fung. Eur.*, No. 1767, 1873.

Uredo Cyani Schleich., *Plant Helv.*, p. 95, 1805. *Puccinia Hieracii* Mart., *Fl. Mosq.*, p. 226, 1817, *p.p.* *P. suavolens* Rostr. var. *Cyani* Magnus, in Plow., *Mon. Ured.*, p. 183, 1889.

0. Spermogones amphigenous, sparse, scattered, honey-coloured.

II. Uredosori amphigenous, chiefly hypophyllous, cinnamon-brown, circular or elliptical, scattered, seldom crowded, pulverulent, up to 1·5 mm. diam., surrounded by the ruptured epidermis, soon naked. Spores globose, subglobose, or elliptical, 22–27 × 19–24 mmm.; epispore delicately and sparsely echinulate, 1·5 mmm. thick, with 2 equatorial germ-pores on one face.

III. Teleutosori amphigenous and caulicolous, chocolate-brown, circular to elliptical, scattered, seldom crowded, pulverulent, 0·5–1·5 mm. diam., surrounded by the ruptured epidermis, soon naked. Spores broadly elliptical, 32–38 × 24–29 mmm.; apex rounded, not thickened, base rounded, both cells same size and colour, very regular in shape; not or very slightly constricted at the septum; epispore densely and minutely verruculose, 3 mmm. thick, chestnut-brown, cell-contents coarsely granular; pedicel deciduous, hyaline, fragile, up to 40 × 7 mmm.; germ-pore of upper cell apical or half-way down side, conspicuous, basal pore one-third to two-thirds below septum, conspicuous.

X. Mesospores rare, elliptical, 30–35 × 25 mmm.; rounded at apex and base.

Host: *Centaurea Cyanus* L. On leaves and stems. Herb. No. 3. II, III. Palmerston North (Wellington), 14 April, 1919. Claudelands (Auckland), 27 Feb., 1921. *G. H. C.*

Distribution: Australia; Europe; North America.

The spores of this species are very regular in shape, and appear to vary but slightly in size. This rust was first included as a variety under *P. Hieracii*, but was separated on account of its possessing a thick, verruculose epispore, and because of its inability to infect any host other

than *Centaurea.* The mycelium of the primary uredosori permeates the whole plant, but does not appear to check flowering (Grove, 1913, p. 141).

Characterized by the thick verruculose epispore, and rounded non-thickened apex of the teleutospore.

46. Puccinia distincta McAlpine. (Fig. 64.)

McAlp., *Agr. Gaz. N.S.W.*, vol. 6, p. 853, 1895.

0. Unknown.

I. Aecidia amphigenous, on discoloured spots, scattered, or more frequently aggregated into closely-packed irregular groups, orange. Peridia cupulate, margins white, reflexed, lacerate. Spores subglobose to elliptical, 14–20 × 13–16 mmm.; epispore minutely and densely verruculose, hyaline, 1·5 mmm. thick, cell-contents vacuolate, orange-yellow.

III. Teleutosori amphigenous and on petioles, associated with aecidia, scattered or confluent, elliptical, 1·5 mm. long, black, bullate, compact, becoming exposed by the epidermis fissuring longitudinally. Spores clavate or fusoid, 38–55 × 17–22 mmm.; apex rounded, truncate, or acuminate, frequently oblique, thickened up to 10 mmm., and darker in colour, base attenuate, basal cell narrower and lighter in colour than upper, cell-contents granular; slightly or not constricted at the septum; epispore smooth, chestnut-brown, 1·5–2·5 mmm. thick, thinner in lower cell; pedicel persistent, tinted, stout, up to 55 × 8 mmm., continuous with spore; germ-pore of upper cell apical, conspicuous, basal pore immediately below the septum, obscure, usually papillate.

X. Mesospores common, clavate or obovate, 30–35 × 14–18 mmm.; apex acuminate and thickened; pedicel persistent.

Host: *Bellis perennis* L. On leaves, scapes, and petals. Herb. Nos. 184, 375. I. Levin; Masterton (Wellington), *G. H. C.* Sept., 1919. I, III. Tiritea, Palmerston North (Wellington), *G. H. C.* 3 Mar., 1921. Nelson, *Miss K. M. Curtis!* 30 May, 1921.

Distribution: Australia; Tasmania.

The host is an introduced plant, and is a common weed in pastures. Characterized by the thickened apex, thin, smooth epispore, and clavate or fusoid shape of the teleutospore.

47. Puccinia egmontensis n. sp. (Fig. 65.)

0. Spermogones amphigenous, in irregular groups on inflated spots, erumpent, scattered or crowded, honey-coloured.

III. Teleutosori amphigenous, in irregular groups on somewhat inflated yellow spots, surrounded by the spermogones, circular, or irregularly elliptical, sometimes circinnate, up to 2 mm. diam., pulvinate, compact, black, surrounded by the ruptured epidermis. Spores clavate, 55–65 × 15–22 mmm.; apex bluntly rounded, seldom acuminate, thickened up to 10 mmm., darker in colour, base attenuate, basal cell longer, narrower, and lighter in colour than the upper, cell-contents granular, nuclei conspicuous; slightly constricted at the septum; epispore smooth, 1·5–2 mmm. thick in the upper cell, 1–1·5 mmm. in lower, chestnut-brown; pedicel persistent, hyaline, 50 × 5 mmm., continuous with spore; germ-pore of the upper cell apical, obscure, basal pore immediately below the septum, obscure.

X. Mesospores common, elliptical or fusoid, 30–40 × 12-16 mmm.; apex acuminate.

Host: *Celmisia glandulosa* Hook. f. On leaves. Herb. No. 491. III. Mount Egmont (Taranaki), 1,170 m., *W. D. Reid! N. R. Foy!* 3 Jan., 1922. (Type.)

The host is endemic, and confined to the mountain regions of both Islands. Characterized by the thickened, rounded apex, thin epispore, and clavate shape of the teleutospore, and the absence of aecidia and uredospores.

48. Puccinia Erechtitis McAlpine. (Fig. 66.)

McAlp., *Proc. Roy. Soc. Vic.*, vol. 7 (n.s.), p. 216, 1894.

0. Spermogones epiphyllous, in groups on discoloured spots, honey-coloured.

I. Aecidia amphigenous and caulicolous, orange-yellow, crowded in irregular groups on inflated areas, which may attain a diam. of 20 mm. or more. Peridia cupulate, margins white, lacerate, revolute. Spores polygonal or elliptical, 16–19 × 12–17 mmm.; epispore 1 mmm. thick, hyaline, closely and densely verruculose, cell-contents vacuolate, orange-yellow.

III. Teleutosori amphigenous, chiefly caulicolous, in irregular groups mixed with aecidia, crowded, elliptical, 1 mm. long, becoming confluent, compact, pulvinate, black, long covered by the epidermis. Spores clavate, 40–51 × 17–25 mmm.; apex rounded, truncate, or acuminate, thickened up to 10 mmm., base attentuate, basal cell narrower and lighter in colour, cell-contents granular; constricted at the septum; epispore smooth, chestnut-brown, 2–2·5 mmm. thick in upper cell, 1–1·5 mmm. in lower; pedicel persistent, tinted, 40 × 9 mmm., continuous with spore; germ-pore of the upper cell apical, obscure, basal pore immediately below the septum, obscure.

X. Mesospores common, fusoid, or elliptical, 32–43 × 13–17 mmm.; apex thickened.

Host: *Erechtites prenanthoides* (A. Rich.) DC. On leaves and stems. Herb. No. 178. I, III. Stewart Island, *T. Kirk!* 1886.

Distribution: Australia; Tasmania.

The host is indigenous and widespread; it occurs also in Australia and Tasmania (Cheeseman, 1906, p. 364).

Closely related to *Puccinia tasmanica* Diet., on *Senecio* spp., but differing in several minor details. The teleutospores are somewhat shorter and have a somewhat thinner epispore than *P. tasmanica*.

49. Puccinia fodiens n. sp. (Fig. 67.)

0, I, Unknown.

II. Uredosori amphigenous, seated on discoloured spots, scattered or in more or less circinnate groups, circular, bullate, pulverulent, cream-coloured, long covered by the tomentum of the leaf, up to 5 mm. diam. Spores subglobose to globose, frequently obovate, 25–38 × 26–29 mmm.; epispore sparsely and coarsely echinulate, 3–4 mmm. thick, hyaline, cell-contents pallid yellow, with 2–3 scattered germ-pores on one face.

III. Teleutosori similar to the uredosori but chestnut-brown. Spores broadly elliptical, 40–55 × 28–35 mmm.; apex obtusely acuminate, often rounded, thickened up to 10 mmm., base rounded, seldom attenuate, both cells same size and colour; not constricted at the septum; epispore punctate, 3–4 mmm. thick, chestnut-brown, cell-contents granular, nuclei

conspicuous; pedicel deciduous, hyaline, delicate, up to 30 × 8 mmm.; germ-pore of the upper cell apical or one-third below apex, conspicuous, basal pore immediately below or one-third way below the septum, conspicuous.

Host: *Celmisia rigida* (T. Kirk) Cockayne. On leaves. Herb. No. 376. II, III. Botanical Gardens, Queenstown (Otago), *G. H. C.* 3 Dec., 1919. (Type.)

The host is an endemic species. The sori are covered by the dense tomentum which clothes the leaf-surfaces. Teleutospores are rare, and occur in the same sori as the uredospores.

Characterized by the thickened apex, punctate epispore, and large size of the teleutospores.

50. Puccinia hectorensis n. sp. (Fig. 68.)

0. Unknown.

I. Aecidia hypophyllous and on petioles, scattered or in irregular groups, sparse, dingy yellow. Peridia cylindrical, standing above the leaf-surface 1 mm. or more, up to 0·5 mm. diam., cream-coloured, margins erect, lacerate. Spores polygonal, 30–40 × 20–30 mmm.: epispore dingy yellowish-brown, 2 mmm. thick, densely and finely verruculose.

III. Teleutosori hypophyllous, ochraceous, scattered, circular, up to 1·5 mm. diam., compact, long covered by the dense tomentum of the leaf. Spores linear-oblong, 100–140 × 20–32 mmm.; apex bluntly rounded, not or scarcely thickened, base subattenuate, lower cell somewhat narrower than upper, cell-contents granular, pale orange; slightly constricted at the septum; epispore smooth, 1·5–2 mmm. thick, hyaline: pedicel persistent, hyaline, up to 100 × 10 mmm., continuous with the spore; germ-pore of upper cell apical, obscure, basal pore immediately below the septum, obscure.

X. Mesospores common, 60–85 × 16–24 mmm.; apex bluntly rounded.

Host: *Senecio Bidwillii* Hook. f. On leaves and petioles. Herb. No. 495. I, III. Mount Dennan, Tararua Mountains (Wellington), 1,200 m., *E. H. Atkinson!* 7 Jan., 1922. (Type.)

The host is endemic, and is confined to the mountain regions of both Islands (Cheeseman, 1906, p. 383). The teleutospores germinate immediately they reach maturity. This species shows a general resemblance to *Puccinia novae-zelandiae* G. H. Cunn., but is readily distinguished by the linear-oblong spores, which attain a length of 140 mmm.

51. Puccinia Hypochoeridis Oudemans. (Fig. 69.)

Oud., in *Nedler. Kruidk. Archief.*, vol. 2, ser. 1, p. 175, 1872.

Puccinia Microseris McAlp., *Agr. Gaz. N.S.W.*, vol. 6, p. 757, 1895.

0, I. Unknown.

II. Uredosori amphigenous, scattered, pulverulent, circular or elliptical, up to 1·5 mm. diam., chestnut-brown, surrounded by the ruptured epidermis. Spores globose to elliptical, 20–28 × 18–25 mmm.; epispore densely and minutely verruculose, chestnut-brown, 1·5–2 mmm. thick, cell-contents granular, with 2 usually papillate equatorial germ-pores.

III. Teleutosori amphigenous, scattered, circular or elliptical, up to 1 mm. diam., chocolate-brown, pulvinate, compact, surrounded by the ruptured epidermis. Spores elliptical or subclavate, 28–42 × 18–25 mmm.; apex rounded, not thickened, base attenuate, commonly rounded, both

cells same colour, lower slightly narrower, cell-contents granular, nuclei evident; slightly or not constricted at the septum; epispore minutely and densely verruculose, chestnut-brown, 1·5–2 mmm. thick; pedicel persistent, hyaline, delicate, up to 42 × 6 mmm.; germ-pore of the upper cell apical or frequently one-third way down the side, conspicuous, basal pore one-half to two-thirds way below septum, conspicuous, both usually papillate.

Host: *Hypochoeris glabra* L. On leaves and stems. Herb. No. 440. II, III. Dunstan Mountains (Otago), 600 m., *W. D. Reid!* 5 Dec., 1921.

Distribution: Australia; North America; Europe; Chile; Siberia.

The host is an introduced plant, and is a common weed in pastures. The epispore is seen to be distinctly verruculose when the teleutospores are mounted dry and examined. This species is difficult to separate from several closely related species which occur on related genera of the host plant; in fact, many of these so-called species are separated on biological distinctions alone, so that determination of many is dependent on determination of the host. The verruculose epispore, rounded apex, and somewhat clavate form of the teleutospore characterizes this and several closely related species; correct determination of the host fixes the species.

52. **Puccinia Lagenophorae** Cooke. (Fig. 70.)

Cke., *Grev.*, vol. 13, p. 6, 1884.

Puccinia Hypochoeridis McAlp., *Proc. Roy. Soc. Vic.*, vol. 7, p. 217, 1894.
P. Macalpini Syd., *Mon. Ured.*, vol. 1, p. 100, 1902.

0. Spermogones amphigenous, associated with the aecidia, on pale-yellow spots, immersed, minute, honey-coloured.

I. Aecidia amphigenous, scattered or more commonly in groups on pale-yellow spots. Peridia up to 200–240 mmm. diam., cupulate, margins white, slightly revolute, laciniate. Spores subglobose to shortly elliptical, 17–19 × 14 mmm.; epispore hyaline, finely and densely verruculose, 1 mmm. thick, cell-contents pallid yellow.

III. Teleutosori amphigenous and caulicolous, chestnut-brown, circular or elliptical, on stems scattered or aggregated into irregularly circular groups, pulvinate, compact, up to 2 mm. diam., surrounded by the ruptured epidermis. Spores subclavate, seldom elliptical, 34–46 × 15–22 mmm.; apex rounded, truncate, or often bluntly acuminate, thickened up to 7 mmm., more deeply coloured than rest of spore, base attenuate, basal cell narrower and somewhat longer and lighter in colour than upper, cell-contents vacuolate; constricted at the septum; epispore smooth, 2·5–3 mmm. thick in upper cell, 2–2·5 mmm. in lower, chestnut-brown; pedicel persistent, tinted, stout, up to 35 × 8 mmm., continuous with spore; germ-pore of the upper cell apical, obscure, basal pore immediately beneath the septum, obscure.

X. Mesospores common, clavate to obovate, 32–38 × 17–22 mmm.; apex thickened.

Hosts:—

Lagenophora Barkeri T. Kirk. On leaves and stems. Herb. Nos. 177, 300. I, III. Porter River (Canterbury), *T. Kirk!* 21 Feb., 1881.

Lagenophora petiolata Hook. f. On leaves. I, III. Mount Judah (Otago), 1,000 m., *W. D. Reid!* 14 Dec., 1921.

Lagenophora pumila (Forst. f.) Cheeseman. On leaves, petioles, and stems. I. Bravo Island, *T. Kirk!* Dunstan Mountains (Otago), 500 m., *A. H. Cockayne!* 6 Feb., 1921. I, III. Table Bay, 840 m.; Dunstan Mountains (Otago), *W. D. Reid!* April, Dec., 1921.

Distribution: Australia; Tasmania.

All three hosts are endemic, *L. Barkeri* being confined to the South Island (Cheeseman, 1906, p. 272–73). A large number of mesospores are present in the sori. Although in the original description Cooke describes uredospores, neither McAlpine nor I have been able to find them, so they have been omitted from the above description. There are no type specimens of this species in the Kew Herbarium, so that the matter must remain at issue. The teleutospore-measurements given above differ considerably from those given by McAlpine (1906, p. 162), his measurements being 36–63 × 15–25 mmm.

53. **Puccinia Lapsanae** Fuckel. (Fig. 71.)

Fcl., *Symb. Myc.*, p. 53, 1869.

Aecidium Lapsanae Schultz, *Prodr. Fl. Stangard.*, p. 454, 1806. *A. compositarum Lapsanae* Purton: Cke., in *Jour. Bot.*, vol. 2, p. 38, 1864. *Trichobasis Lapsanae* Cke., *Micr. Fungi*, ed. 4, p. 224, 1865. *Puccinia Lampsanae* Fcl., in *Sacc.*, *Syll.*, vol. 7, p. 607, 1888. *Dicaeoma Lapsanae* (Schultz) Kuntze, *Rev. Gen.*, vol. 3, p. 469, 1898.

0. Spermogones amphigenous, in small groups on discoloured spots, honey-coloured.

I. Aecidia amphigenous, seated on purplish, inflated spots, and on veins and petioles, arranged in circular or linear groups. Peridia explanate, margins reflexed, white, deeply and irregularly laciniate. Spores globose, elliptical, or polygonal, 15–28 × 13–26 mmm.; epispore hyaline, minutely verruculose, 1–1·5 mmm. thick, cell-contents orange.

II. Uredosori amphigenous, cinnamon-brown, circular, sometimes irregular, scattered, seldom confluent, pulverulent, 0·25–0·5 mm. diam., surrounded by the ruptured epidermis. Spores subglobose or elliptical, 18–23 × 15–19 mmm.; epispore delicately and sparsely echinulate, 1·5 mmm. thick, cinnamon-brown, with 2 frequently papillate equatorial germ-pores on one face.

III. Teleutosori amphigenous, chocolate-brown, circular, scattered, pulverulent, 0·25–0·5 mmm. diam., surrounded by the ruptured epidermis. Spores elliptical, subglobose, or obovate, 20–32 × 17–25 mmm.; apex rounded, not thickened, base rounded, both cells same size and colour, cell-contents granular; slightly or not constricted at the septum; epispore minutely verruculose, 1·5–2 mmm. thick, chestnut-brown; pedicel deciduous, hyaline, up to 30 × 5 mmm.; germ-pore of upper cell apical, or frequently one-quarter way down side, basal pore one-third below septum, both conspicuous and frequently papillate.

X. Mesospores rare, obovate, or elliptical, 16–22 × 17–20 mmm.; apex rounded, not thickened.

Host: *Lapsana communis* L. On leaves. Herb. No. 185. II, III. Motueka (Nelson), *G. H. C.* 28 Jan., 1920. II. Levin (Wellington), *G. H. C.* 1 Mar., 1920. II, III. Palmerston North (Wellington), *R. Waters!* 27 Jan., 1921.

Distribution: Europe; North America; Japan; Syria.

The aecidia have not been collected in New Zealand. The host is an introduced plant, and is a common weed in waste places throughout

the warmer parts of New Zealand. The epispore is seen to be minutely verruculose when the teleutospores are mounted dry and examined. Closely resembles *P. Hypochoeridis* (see remarks under this species), but differs chiefly in the smaller teleutospores and presence of aecidia.

54. Puccinia novae-zelandiae n. sp. (Fig. 72.)

0. Spermogones epiphyllous, sparse, scattered, honey-brown.

I. Aecidia epiphyllous, sparsely arranged in scattered groups on discoloured circular areas. Peridia tubular, standing above the leaf-surface 1 mm., 300 mmm. diam., becoming irregular in shape, margins white, strongly revolute, deeply and irregularly laciniate, finally coming to resemble the form genus *Roestelia*. Spores polygonal, elliptical, or obovate, 25–35 × 15–22 mmm.; epispore minutely and densely verruculose, 1·5–2 mmm. thick, hyaline, cell-contents lemon-yellow.

III. Teleutosori hypophyllous, reddish-orange, circular to elliptical, scattered, pulverulent, up to 0·5 mm. diam., deeply buried in the dense tomentum of the under-surface of the leaf. Spores elliptical to oblong-clavate, 55–93 × 25–37 mmm.; apex rounded, not thickened, base rounded, seldom subattenuate, basal cell usually the same size as upper, rarely narrower; constricted at the septum; epispore smooth, 2–3 mmm. thick, hyaline, cell-contents old-gold colour, granular; pedicel persistent, hyaline, stout, up to 95 × 12 mmm.; germ-pore of upper cell apical, conspicuous, basal pore immediately below the septum, conspicuous.

X. Mesospores common, obovate to pyriform, 45–55 × 30–37 mmm.; apex rounded, not thickened, cell-contents old-gold colour.

Host: *Olearia Forsteri* Hook. f. On leaves. Herb. No. 310. I, III. Coast, Pencarrow (Wellington), *E. H. Atkinson!* 10 Feb., 1921. (Type.)

The host is endemic, and fairly widespread over both Islands (Cheeseman, 1906, p. 292). The spores germinate immediately on reaching maturity, and in some of the sori it is difficult to find a spore that has not germinated. The basidia are of the same colour as the cell-contents, and measure 100 × 20 mmm., the sterigmata may attain a length of 15 mmm., and the basidiospores are obovate and measure 20 × 15 mmm. (fig. 2). The teleutospores somewhat resemble those of *Puccinia Oleariae* McAlp., but the presence of aecidia and the absence of uredospores, besides numerous differences in the teleutospores, serve to separate the two. I am indebted to Mr. L. Rodway, Government Botanist, Tasmania, and to Mr. C. C. Brittlebank, Plant Pathologist, Melbourne, for specimens of *P. Oleariae*. This rust is characterized by the very large size of the teleutospores, hyaline smooth epispore, and old-gold cell-contents.

55. Puccinia obtegens Tulasne. (Fig. 73.)

Tul., in *Ann. Sci. Nat.*, ser. 4, vol. 2, p. 87, 1854.

Uredo suavolens Pers., *Obs.*, vol. 2, p. 24, 1799. *U. punctiformis* Strauss, in *Wett. Ann.*, vol. 2, p. 103, 1810. *Caeoma obtegens* Link., *Obs.*, vol. 2, p. 27, 1816. *Trichobasis suavolens* Lev.: Cooke, in *Handbk.*, p. 530, 1871. *Puccinia suavolens* Rostr., in *Forhandl. Skand. Naturf.* vol. 2, p. 339, 1874.

0. Spermogones amphigenous, scattered over the whole leaf-surface, honey-coloured, sweet-scented.

II. Uredosori hypophyllous, cinnamon-brown, at first scattered, 1 mm. diam., crowded, circular, becoming confluent and covering the entire under-surface of the leaf, pulverulent, surrounded by the ruptured epidermis.

Spores subglobose or broadly elliptical, rarely obovate, 22–30 × 18–28 mmm.; epispore delicately and somewhat closely echinulate, 1·5 mmm. thick, up to 3 mmm. above pedicel, cinnamon-brown, with 2–3 scattered germ-pores on one face.

III. Teleutosori hypophyllous, at first minute, 1 mm. diam., circular, scattered, becoming confluent, finally whole leaf-surface becoming covered, chestnut-brown, pulverulent. Spores elliptical or oblong, 28–40 × 18–25 mmm.; apex rounded, not thickened, base rounded, basal cell

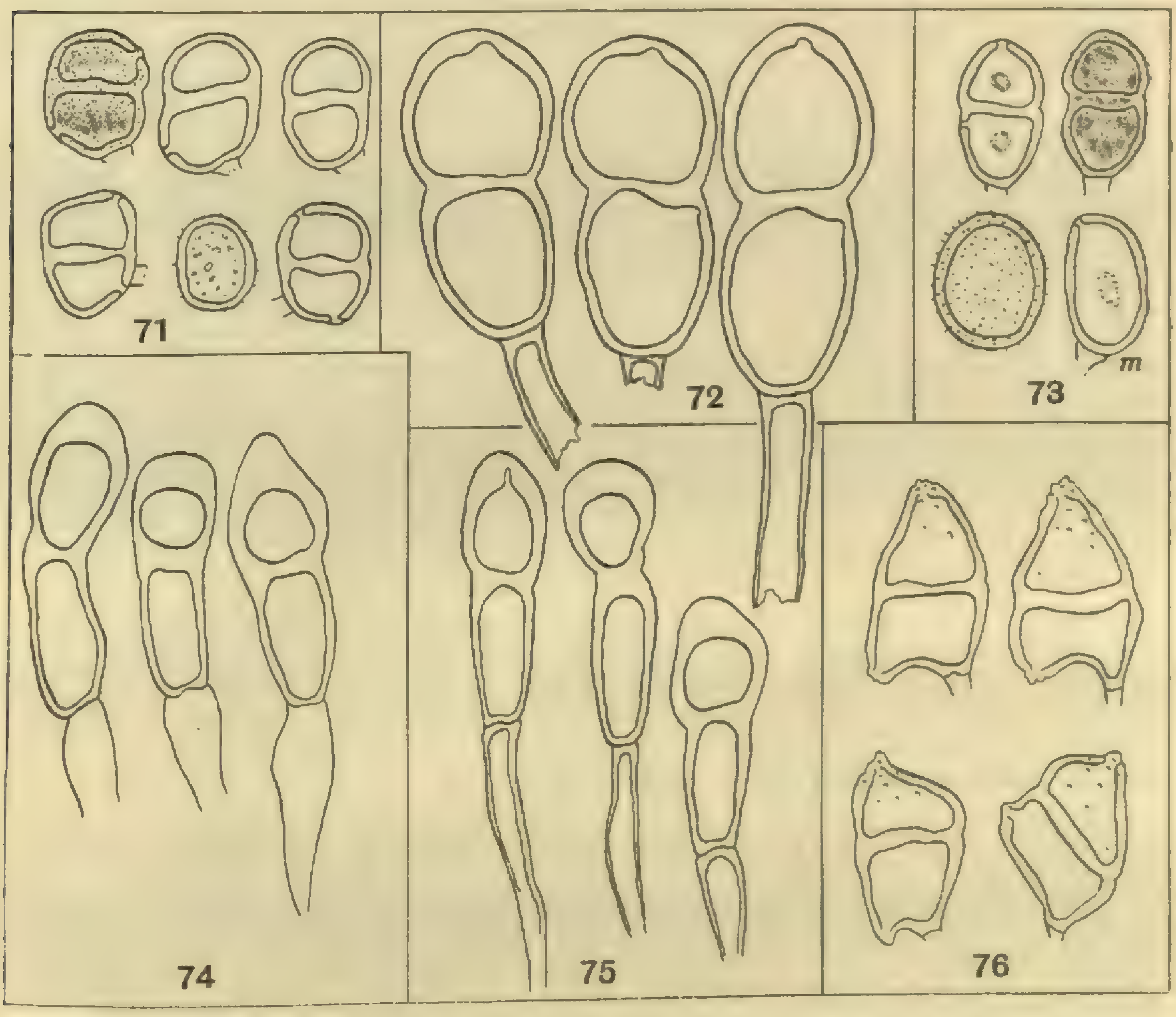

FIG. 71.—*Puccinia Lapsanae* Fcl. Uredo- and teleuto-spores from *Lapsana communis* L.
FIG. 72.—*Puccinia novae-zelandiae* sp. nov. Teleutospores from *Olearia Forsteri* Hook. f. × 325.
FIG. 73.—*Puccinia obtegens* Tul. Uredo- and teleuto-spores from *Cnicus arvensis* Hoffm.
FIG. 74.—*Puccinia pounamu* sp. nov. Teleutospores from *Senecio southlandicus* Cockayne.
FIG. 75.—*Puccinia tasmanica* Diet. Teleutospores from *Senecio lautus* Forst. f.
FIG. 76.—*Gymnoconia Peckiana* (Howe) Trotter. Teleutospores from *Rubus villosus* Ait.

Camera-lucida drawings by author. All, with exception of fig. 72, × 500.
m = mesospore.

same size as upper; slightly constricted at the septum; epispore verruculose, 1–1·5 mmm. thick, chestnut-brown, cell-contents granular, nuclei prominent; pedicel deciduous, hyaline, short, up to 45 × 6 mmm.; germ-pore of upper cell apical, or frequently obliquely placed, basal pore immediately below septum, both conspicuous.

X. Mesospores uncommon, elliptical, 22–28 × 17–22 mmm.; rounded, or sometimes truncate at the apex, not thickened.

Host: *Cnicus arvensis* Hoffm. On leaves and stems. Herb. No. 221. II, III. Weraroa (Wellington), *A. H. Cockayne!* 9 May, 1919. Roxburgh (Otago), *J. Fleming!* 17 Jan., 1921. Turakina (Wellington), *S. A. Cunningham!* 4 Dec., 1921.

Distribution: Europe; Siberia; North America; Japan; Australia.

The host is introduced, and is a troublesome weed throughout the agricultural areas of New Zealand. The rust is of considerable economic importance, as once it has become established in a patch of thistles it persists year after year and prevents seed-formation in the flowering-heads. Infected plants may readily be recognized, as they become etiolated and lighter in colour than normal plants.

There are two distinct phases in the life-cycle of this species. Early in the spring primary uredosori arise from basidiospores produced from the previous season's teleutospores. These sori cover the greater part of the lower surface of the leaf, and the mycelium permeates the whole plant. This phase is accompanied by spermogones, which are said to give off a strong and pleasant odour. From the primary uredospores arise secondary sori producing both uredo- and teleuto-spores. These secondary sori are scattered and their mycelium is localized, consequently but little damage is done to the plant. This phase is not accompanied by spermogones. Infection from the teleutospores of these secondary sori occurs the following spring, when the young shoots and plants are infected. At one time it was believed that this rust was perpetuated by means of hybernating mycelium in the rhizomes; later investigations have disproved this theory. The verruculose epispore, non-thickened apex, and regular, elliptical shape of the teleutospore characterize this species.

56. Puccinia pounamu n. sp. (Fig. 74.)

0. Spermogones hypophyllous, sparse, scattered, immersed, honey-coloured.

III. Teleutosori amphigenous, chiefly hypophyllous, arranged in scattered groups on discoloured areas which are usually surrounded by a yellow margin, circular, minute, 0·5 mm. diam., pulvinate, compact, chestnut-brown, surrounded by the ruptured epidermis. Spores elongate-clavate or elliptical, 47–65 × 14–29 mmm.; apex rounded, seldom bluntly acuminate, thickened up to 10 mmm., base attenuate, lower cell narrower and somewhat longer than upper; slightly or not constricted at the septum; epispore smooth, tinted brown, almost hyaline, 2–2·5 mmm. thick; pedicel persistent, hyaline, stout, up to 50 × 12 mmm., continuous with spore; germ-pore of upper cell apical, obscure, basal pore immediately below septum, obscure.

Host: *Senecio southlandicus* Cockayne. On leaves. Herb. No. 426. III. Greenstone Valley (Otago), 500 m., *W. D. Reid!* 5 April, 1921. (Type.)

The host is endemic.

The teleutospores germinate immediately on reaching maturity. A rather conspicuous feature is the presence, in a number of spores, of an inflated pedicel (fig. 74).

Characterized by the smooth epispore, thick apex, attenuate base, and stout persistent pedicel of the teleutospore.

57. Puccinia tasmanica Dietel. (Figs. 4, 75.)

Diet., *Ann. Myc.*, vol. 1, p. 535, 1903.

0. Spermogones amphigenous and caulicolous, erumpent, scattered, honey-coloured.

I. Aecidia amphigenous and caulicolous, forming inflated orange spots on leaves, and linear inflated and distorted areas up to 10 mm. or more in length on the stems, scattered or more commonly closely aggregated. Peridia cupulate, up to 300 mmm. diam., margins tinted yellow, strongly revolute, irregularly laciniate. Spores subglobose to polygonal, 14–17 × 12–15 mmm.; epispore minutely and densely verruculose, 1–1·5 mmm. thick, hyaline or tinted yellow, cell-contents orange.

III. Teleutosori caulicolous, less commonly amphigenous, frequently intermixed with aecidia, forming linear distorted areas up to 2 cm. in length, black, pulvinate, compact, for a long time covered, finally becoming exposed by the epidermis falling away in irregular shreds. Spores elongate-clavate, 40–60 × 13–28 mmm.; apex bluntly rounded, commonly truncate, seldom acuminate, at times oblique, thickened up to 14 mmm., darker in colour, base attenuate, basal cell longer, narrower, and lighter in colour than the upper; constricted at the septum; epispore smooth, up to 3 mmm. thick in upper cell, 1·5–2 mmm. in lower, chestnut-brown, cell-contents vacuolate; pedicel persistent, tinted, stout, up to 60 × 11 mmm., continuous with spore; germ-pore of upper cell apical, obscure, basal pore immediately below septum, obscure.

X. Mesospores common, elliptical to obovate, 30–42 × 12–16 mmm.; apex rounded, thickened.

Hosts:—

Senecio lautus Forst. f. On leaves, stems, peduncles, and involucral bracts. Herb. Nos. 181, 293, 404. I, III. Wellington Heads, *E. H. Atkinson!* 11 April, 1920. I. Cashmere Hills (Canterbury), 400 m., *W. D. Reid!* 31st July, 1921. Seatoun (Wellington), *G. H. C.* 27 Jan., 1921.

Senecio vulgaris L. On leaves and stems. I, III. Weraroa (Wellington). 21 Oct., 1919. I. Kelburn (Wellington), *G. H. C.* Jan., June, Oct., Nov., 1921.

Distribution: Australia; Tasmania.

One host is indigenous and widespread, the other is a weed common in gardens and waste places. One commonly sees "groundsel" plants killed outright by the aecidial stage of this rust. Although plants of *S. lautus* attacked by the aecidia are distorted and stunted, they are seldom killed outright. This species differs from *P. Senecionis* Lib. in the thickened apex, larger size, and persistent pedicels of the teleutospores.

4. GYMNOCONIA Lagerheim.

Lagerh., *Tromosoe Mus. Aarsh.*, vol. 16, p. 140, 1894.

Autoecious. Cycle of development includes 0, I, III.

0. Spermogones columnar, erumpent, aparaphysate, honey-coloured.

I. Caeomata without peridia, aparaphysate; large, erumpent, indefinite. Spores catenulate, commonly polygonal; epispore verruculose, hyaline.

III. Teleutosori erumpent, pulverulent, definite. Teleutospores two-celled, borne singly on distinct pedicels; epispore smooth, or with a few small warts, coloured; germ-pores one to a cell, papillate.

New Zealand species, 1 (introduced).

This genus is separated from *Puccinia* on account of the peridia being absent from the aecidia, and because of the absence of uredospores. The teleutospores are peculiar in that they are more or less triangular, the base being at one angle formed by the attachment of the pedicel; the other angle being formed by the protrusion of the epispore into a short projection, at the end of which is the germ-pore.

1. **Gymnoconia Peckiana** (Howe) Trotter. (Fig. 76.) Rosaceae (1).

A. Trotter, *Fl. Ital. Crypt.*, Pars. 1 Fungi., Fasc. 7, Ured., p. 337, 1910.

Uredo interstitialis Schlecht., *Horae Phys., Berol.*, p. 96, 1820. *Aecidium nitens* Schw., *Schr. Nat. Ges. Leipsig*, vol. 1, p. 69, 1822. *Caeoma luminatum* Link., in Wild., *Sp. Pl.*, vol. 6, p. 61, 1825. *Puccinia Peckiana* Howe: Peck, *Ann. Rep. N.Y. State Mus.*, vol. 23, p. 57, 1872. *P. tripustulata* Peck, *Ann. Rep. N.Y. State Mus.*, vol. 24, p. 91, 1872. *Caeoma nitens* Burrill, *Bull. Ill. Lab. Nat. Hist.*, vol. 2, p. 220, 1885. *Puccinia interstitialis* Tranz., *Hedw.*, vol. 32, p. 259, 1893. *Gymnoconia interstitialis* (Schlecht.) Lagerh., *Tromosoe Mus. Aarsh.*, vol. 16, p. 140, 1894. *Dicaeoma tripustulatum* Kuntze, *Rev. Gen.*, vol. 3, p. 467, 1898. *Kunkelia nitens* Arth., *Bot. Gaz.*, vol. 63, p. 501, 1917.

0. Spermogones amphigenous, scattered, columnar, honey-coloured, conspicuous.

I. Caeomata amphigenous, chiefly hypophyllous and caulicolous, scattered or more frequently crowded, up to 1·5 mm. diam., erumpent, orange-yellow, surrounded by the ruptured epidermis. Spores globose to polygonal, 20 – 30 × 17 – 24 mmm.; epispore 1 – 1·5 mmm. thick, hyaline, densely verruculose, cell-contents bright orange, germ-pores scattered, numerous, obscure.

III. Teleutosori hypophyllous, on discoloured spots, scattered, rarely confluent, circular, minute, up to 0·25 mm. diam., pulverulent, chestnut-brown, soon naked. Teleutospores irregularly triangular, seldom elliptical, 35–45 × 20–26 mmm.; apex bluntly acuminate, seldom rounded, not thickened, but crowned with 1 or several hyaline papillae, base very irregular in shape, attenuate, bluntly rounded or coarsely retuse, upper cell usually somewhat triangular, basal cell distorted near the pedicel by a protrusion of the wall; epispore covered with a few coarse warts, more prominently near the germ-pores, 1–1·5 mmm. thick, golden-brown, cell-contents coarsely granular; slightly or not constricted at the septum; pedicel deciduous, hyaline, fragile, up to 60 × 5 mmm; germ-pore of the upper cell apical, conspicuous, basal pore from half-way to two-thirds below septum, usually at end of protrusion of epispore, conspicuous, both usually papillate.

Host: *Rubus fruticosus* L. On leaves and stems. Herb. No. 246. I. Tokomaru (Wellington), *G. H. C.* 6 Dec., 1920. Auckland, *G. H. C.* 2 Mar., 1921. Helensville (Auckland), *E. Bruce Levy.* Feb., 1921.

Distribution: North America; Europe; Asia.

In North America two biological forms of this rust occur. The caeomaspores of one form on germination produce short basidia on which basidiospores are produced; these basidiospores on coming in contact with the host give rise to further caeomata; so that the caeomaspores appear to function as teleutospores. The caeomaspores of the second form on germination produce germ-tubes which, on the host, produce teleutosori.

LATIN DESCRIPTIONS.

1. Uromyces Discariae sp. nov. (Fig. 15, and Plate 77, fig. 1.)

0. Spermagoniis hypophyllis, aecidis praecessis, confertis, saepe circinnatis, minutis, immersis, subflavis.

I. Aecidiis hypophyllis, in flavis maculis quae desuper cerri possunt solide confertis. Peridiis cylindraceis, super superficiem exstitis a 1 mm., luteis, marginibus erectis, hyalinis, dentatis. Aecidiosporis polygoniis vel globosis, 26–32 × 22–26 mmm.; episporio hyalino, 1·5–2 mmm. crasso, dense minuteque verrucoso, contentu luteo, vacuolato.

III. Soris teleutosporiferis hyophyllis, raris, in maculis flavis, spadicibus, pulvinatis, compactis, rotundis v. communiter ellipticis, ad 2 mm. longis, tectis. Teleutosporis ellipticis v. subglobosis, incompositis, 23–33 × 15–21 mmm.; apice acuminato, vel rustice rotundato, crassis ad 10 mmm., basi abrupte attenuato, raro rotundato, nucleo conspicuo; pedicello persistente, tincto, ad 80 × 5 mmm.; foramine germinis apicale, conspicuo.

Hab.: In foliis vivis *Discariae toumatou* Raoul. Queenstown, Otago, New Zealand. *W. D. Reid.*

2. Uromyces otakou sp. nov. (Fig. 7.)

0, I. Incognitis.

II. Uredosoris epiphyllis, raris, raro linearibus, ellipticis, ad 2 mm. longis, luteis, pulverulentibus, epidermide rupta cinctis. Uredosporis globosis v. subglobosis, 20–30 mmm. crassis; episporio dense minuteque verrucusco, 1–1·5 mmm. crasso, hyalino, contentu luteo, cum 5–8 raris foraminibus germinis.

III. Soris teleutosporiferis epiphyllis, raris, raro confluentibus, linearibus, spadicibus, ad 3 mm. longis, pulvinatis, compactis, epidermide rupta cinctis. Teleutosporis obovatis, 24–30 × 19–23 mmm.; apice rotundo, raro rustice acuminato, crassis ad 12 mmm., basi subattenuato, saepe rotundato; episporio leve, crasso 2–5·5 mmm., castaneo; pedicello persistente, tincto, ad 60 × 8 mmm.; foramine germinis apicale, obscuro.

Hab.: In foliis, vaginisque *Poae caespitosae* Spreng. Otago, New Zealand. *W. D. Reid.*

3. Puccinia Allanii sp. nov. (Fig. 58.)

0. Spermagoniis amphigenis, sparsis, aliquantum aecidiis immixis, subflavis.

I. Aecidiis amphigenis, in maculis decolaratis solide confertis, in subrotundis catervis, flavis. Peridiis cupulatis, marginibus expansis sed non revolutis, laceratis, albis. Aecidiosporis polygoniis, saepe subglobosis, 12–18 mmm. latis; episporio verruculoso, 1 mmm. crasso, hyalino, contentu luteo.

III. Soris teleutosporiferis hypophyllis, aecidiis immixis, minutis, 0·25–0·5 mm. latis, rotundis, pulvinatis, compactis, castaneis, epidermide rupta cinctis. Teleutosporis ellipticis, communiter subclavatis, 35–55 × 18–26 mmm.; apice rotundato, saepe rustice acuminato, incrassato ad 10 mmm., basi attenuato, cellula superiore fusciore latioreque quam inferiore; ad septum constricto; episporio leve, castaneo, crasso 2–3 mmm.; pedicello persistente, tincto, ad 50 × 10 mmm.; foramine germinis cellulae superiore apicale, conspicuo, foramine basali statim infra septum, obscuro.

Hab.: In foliis vivis *Senecionis lagopi* Raoul. Banks Peninsula, Canterbury, New Zealand. *H. H. Allan.*

4. Puccinia Atkinsonii sp. nov. (Fig. 59.)

0. Spermagoniis hypophyllis, aecidiis immixis, minutis, immersis, brunneo-subflavis.

I. Aecidiis hypophyllis, in magnis catervis in maculis detorsis quae desuper cerni possunt solide confertis, ad 25 mm. longis, rotundis v. linearibus, luteis. Peridiis immersis, marginibus solis conspectis, ellipticis, ad 800 mmm. latis × 450 mmm. altis, marginibus solidis, erectis. Aecidiosporis sub globosis, ellipticis, saepe lenticularibus cum apiculo longo hyalino, 25–35 × 15–22 mmm.; episporio dense minuteque verrucoso, 2 mmm crasso, hyalino, contentu rubro-luteo, granuloso.

III. Soris teleutosporiferis hypophyllis, in minutis nigro-brunneis maculis, desuper inspectis, nigro-spadicibus fere nigris, rotundis, raris, primum tomento denso folii tectis, ad extremum erumpentibus pulverulentibusque, ad 0·5 mm. latis. Teleutosporis late ellipticis, 40–65 × 20–35 mmm.; apice retuso, non saepe papillato, incrassato ad 7 mmm. necne, basi rotundato, non saepe attenuato, cellulis similibus; ad septum leniter constricto; episporio leve, 2·5–3 mmm. crasso, pallido-castaneo, contentu vacuolato; pedicello deciduo, hyalino, ad 45 × 8 mmm.; foramine germinis cellulae superioris apicale, v. variato inter apicem septumque, foramine basali ferme ⅓ infra septum, cellulis conspicuis et primum papillatis, inde papillis concidentibus notam in episporio super foramen germinis facientibus.

X. Mesosporis raris, subglobosis, ellipticis v. obovatis, 35–55 × 38–45 mmm.

Hab.: In foliis vivis *Oleariae excorticatae* Buch. Mount Hector, Wellington, New Zealand. *E. H. Atkinson.*

5. Puccinia Cockaynei sp. nov. (Fig. 51.)

0. Spermagoniis amphigenis, in maculis flavis, uredosoris immixis v. cinctis, immersis, subflavis.

II. Uredosoris amphigenis, castaneis, rotundis v. ellipticis, minutis, ad 1 mm. latis, raris, pulverulentibus, bullatis, rupta epidermide cinctis. Uredosporis subglobosis, ellipticis v. communiter obovatis, 20–32 × 17–26 mmm.; episporio minute sparseque echinulato, 2 mmm. crasso, cinnamomeo, cum foramine germinis uno, conspicuo.

III. Soris teleutosporiferis amphigenis, praecipue hypophyllis, spadicibus, rotundis v. ellipticis, ad 1 mm. latis, raris, pulverulentibus, rupta epidermide cinctis. Teleutosporis clavatis, non saepe ellipticis, 30–38 × 18–24 mmm.; apice rustice rotundato, saepe rustice attenuato. ad 6 mmm. incrassato, basi attenuato, non saepe rotundato, cellula basali angustiore pallidioreque quam superiorem; ad septum paulum constricto; episporio castaneo, leve, 1·5–2 mmm. crasso, contentu vacuolato, nucleis claris; pedicello deciduo, hyalino, fragile, ad 50 × 8 mmm.; foramine germinis cellulae superioris apicale, conspicuo, foramine basali statim infra septum, conspicuo, saepe papillato.

X. Mesosporis raris, subglobosis v. ellipticis, 18–22 × 16–20 mmm.

Hab.: In foliis vivis *Gentianae corymbiferae* T. Kirk et *G. Griesbachii* Hook. f. Queenstown, Otago, New Zealand. *E. H. Atkinson.*

6. Puccinia contegens sp. nov. (Fig. 35.)

0. Spermagoniis amphigenis, sparsis, aecidiis immixis, subflavis.

I. Aecidiis hypophyllis, confertis, flavis. Peridiis immersis, marginibus incurvis et partim epidermide tectis. Aecidiosporis polygonis v. ellipticis, 17–26 × 15–18 mmm.; episporio hyalino, 2 mmm. crasso, dense minuteque verruculoso, contentu luteo, vacuolato.

III. Soris teleutosporiferis amphigenis, castaneis, pulverulentibus, primum raris, rotundis et rupta epidermide cinctis, inde confluentibus. Teleutosporis ellipticis vel subclavatis, 30–45 × 16–23 mmm.; apice rotundato, saepe obliquiter acuminato, non incrassato, basi rotundato, non saepe attenuato, cellulis similibus; leniter ad septum constrictis; episporio 1–1·5 mmm. crasso, reticulato, castaneo, contentu vacuolato; pedicello persistente, hyalino, fragile, ad 60 × 7 mmm., saepe lateraliter affixo; foramine germinis superioris cellulae apicale, conspicuo, foramine basali $\frac{2}{3}$ infra septum, conspicuo, cellulis saepe papillatis.

X. Mesosporis raris, obovatis, v. subglobosis, circiter 22 × 18 mmm.; episporio reticulato, 1 mmm. crasso, castaneo.

Hab.: In foliis vivis *Ranunculi lappacei* Smith et *R. multiscapi* Hook. f. Canterbury, New Zealand. *W. D. Reid.*

7. Puccinia cuniculi sp. nov. (Fig. 46.)

0. Spermagoniis amphigenis, aecidiis immixis, sparsis, raris, minutis, subflavis.

I. Aecidiis hypophyllis, caulicolisque, dense confertis, in foliis in orbibus in catervis inflatis, aliquantum positis, in maculis decolaratis quae desuper cerni possunt, in caulibus petiolibusque in catervis linearibus inflatisque ad 10 mm. longis. Peridiis cupulatis, marginibus expansis, non revolutis, albis, profunde et incomposite laciniatis. Aecidiosporis subglobosis v. polygoniis, 20–22 mmm. crassis; episporio minute denseque verruculoso, 4 mmm. crasso, hyalino, contentu pallido-flavo.

II. Uredosoris hypophyllis, pallido-flavis, raris, pulverulentibus, ad 0·5 mm. latis, ellipticis v. rotundis, rupta epidermide cinctis. Uredosporis obovatis v. ellipticis, 26–30 × 19–25 mmm.; episporio leniter et aliquantum rustice echinulato, 3 mmm. crasso, hyalino, contentu flavo, cum 3–4 foraminibus germinis, indistinctis.

III. Soris teleutosporiferis hypophyllis, minutis, lenticularibus, spadicibus pulverulentibus, 0·5 mm. longis, diu tectis, ad extremum rupta epidermide expositis. Teleutosporis ellipticis v. subclavatis, 35–45 × 21–26 mmm.; apice rotundato, leniter incrassato, basi attenuato saepe rotundato, cellula basali leniter angustiore quam superiorem; ad septum leniter constricto; episporio leve, 2 mmm. crasso, castaneo, contentu granuloso, nucleis conspicuis; pedicello persistente, hyalino, fragile, ad 50 × 5 mmm.; foramine germinis cellulae superioris apicale, conspicuo, foramine basali $\frac{1}{2}$–$\frac{2}{3}$ infra septum, conspicuo, cellulis saepe papillatis.

Hab.: In foliis vivis, caulis, petiolibusque *Angelicae Gingidium* Hook. f. Canterbury, New Zealand. *E. H. Atkinson.*

8. Puccinia egmontensis sp. nov. (Fig. 65.)

0. Spermagoniis amphigenis, in catervis irregularibus in maculis inflatis congestis, erumpentibus, raris vel congestis, pallido-flavis.

III. Soris teleutosporiferis amphigenis, in catervis irregularibus in maculis flavis inflatis congestis, spermagoniis cinctis, circularibus, vel irregulariter ellipticis, saepe circinnatis, ad 2 mm. latis, pulvinatis, compactis, nigris, epidermide rupta cinctis. Teleutosporis clavatis, 55–65 × 15–22 mmm.; apice rustice acuminato, non saepe acuminato, ad 10 mmm. incrassato, colore fusciore, basi attenuato, cellula basali longiore et angustiore et pallidiore quam superiorem, contentu granuloso, nucleis conspicuis; ad septum paullo constrictis; episporio leve, 1·5–2 mmm. crasso in superiore cellula, 1–1·5 mmm. in inferiore, castaneo-brunneo; pedicello persistente, hyalino, 50 × 5 mmm., in sporo se inclinato; foramine germinis superioris cellulae apicale, obscuro, foramine basali statim infra septum, obscuro.

X. Mesosporis vulgaribus, ellipticis vel fusoideis, 30–40 × 12–16 mmm.; apice acuminato.

Hab.: In foliis vivis *Celmisiae glandulosae* Hook. f. Mount Egmont, New Zealand. *W. D. Reid, N. R. Foy.*

9. **Puccinia fodiens** sp. nov. (Fig. 67.)

0, I. Incognitis.

II. Uredosoris amphigenis, in maculis decoloratis, raris vel in aliquantum circinnatis catervis, rotundis, bullatis, pulverulentibus, subflavis, ad 4 mm. latis, diu tomento folii tectis. Uredosporis subglobosis v. globosis, saepe obovatis, 25–35 × 26–29 mmm.; episporio ferme sparse rusticeque echinulato, 3–4 mmm. crasso, hyalino, contentu flavo, cum 2–3 foraminibus germinis raris.

III. Soris teleutosporiferis uredosoris similibus, castaneo-brunneis. Teleutosporis late ellipticis, 40–55 × 28–35 mmm.; apice obtuse acuminato, saepe rotundato, incrassato, ad 10 mmm., basi rotundato, non saepe attenuato, cellulis similibus; ad septum non constricto; episporio punctato, 3–4 mmm. crasso, castaneo, contentu granuloso, nucleis conspicuis; pedicello deciduo, hyalino, delicato, ad 30 × 8 mmm.; foramine germinis cellulae superioris apicale vel ⅓ infra summum, conspicuo, foramine basali statim v. ⅓ infra septum, conspicuo.

Hab.: In foliis vivis *Celmisiae rigidae* (Kirk) Cockayne. Queenstown, Otago, New Zealand. *G. H. C.*

10. **Puccinia Halorrhagidis** sp. nov. (Fig. 44.)

0. Spermagoniis epiphyllis, caulicolisque, dispersis, raris, immersis, pallido-flavis.

I. Aecidiis hypophyllis, in superficie foliarum dispersis. Peridiis cupulatis, marginibus erumpentibus, aliquantum incurvis, laceratis, luteo suffusis. Aecidiosporis globosis v. subglobosis, 18–22 mmm.; episporio minute verruculoso, 1 mmm. crasso, hyalino, contentu rubro-luteo.

II. Uredosporis amphigenis, praecipue epiphyllis, raris, rotundis, ad 1 mm. latis, bullatis, pulverulentibus, cinnamomeis, rupta epidermide cinctis et partim tectis. Uredosporis globosis vel subglobosis, 20–25 mmm. latis; episporio raro aculeato, 2 mmm. crasso, cinnamomeo, cum 2–3 foraminibus germinis in circulo aequinoctialis.

III. Soris teleutosporiferis uredosoris immixis et similibus. Teleutosporis ellipticis, incompositis, detorisque, 28–42 × 17–27 mmm.; apice rotundato, raro acuminato, non incrassato, basi rotundato, cellula inferior ferme majore quam superiorem; ad septum constricto; episporio leve, 1·5–2·5 mmm. crasso, pallido-castaneo; pedicello deciduo, hyalino, ad 35 × 8 mmm.; foramine cellulae superioris ferme apicale saepe ⅓ infra summum, conspicuo, foramine basali statim ad ⅔ infra septum, conspicuo, cellulis saepe papillatis.

X. Mesosporis vulgaribus, obovatis, apice acuminato, saepe truncato.

Hab.: In foliis vivis *Halorrhagidis depressae* (A. Cunn.) Walp. et *H. erectae* (Murr.) Schindler. Seatoun, Wellington, New Zealand. *E. H. Atkinson, G. H. C.*

11. **Puccinia hectorensis** sp. nov. (Fig. 68.)

0. Incognitis.

I. Aecidiis hypophyllis et petiolibus, sparsis v. in catervis irregularibus congestis, raris, pallido-flavis. Peridiis cylindraceis, super folium 1 mm. exstitis, ad 0·5 mm. latis, pallido-flavis, marginibus erectis, laceratis.

Aecidiosporis polygoniis, 30–40 × 20–30 mmm.; episporio pallido-flavo-brunneo, 2 mmm. crasso, dense minuteque verruculoso.

III. Soris teleutosporiferis hypophyllis, ochraceis, raris, circularibus, 1·5 mm. lateris, compactis, diu denso tomento folii tectis. Teleutosporis linearibus oblongis, 100–140 × 20–32 mmm.; apex rustice rotundato, non vel vix incrassato, basi subattenuato, cellula inferiore paullo angustiore quam superiorem, contentu granuloso, pallido-luteo; paullo constricto ad septum; episporio leve, 1·5–2 mmm. crasso, hyalino; pedicello persistente, hyalino, ad 100 × 10 mmm., in sporo se inclinato: foramine germinis superioris cellulae apicale, obscuro, foramine basali statim infra septum, obscuro.

X. Mesosporis vulgaribus, 60–85 × 16–24 mmm.: apice rustice rotundato.

Hab.: In foliis vivis, petiolibusque *Senecionis Bidwillii* Hook. f. Mount Dennan, Tararua Mountains, New Zealand, 1,200 m. *E. H. Atkinson.*

12. **Puccinia Hoheriae** sp. nov. (Fig. 41, and Plate 77, fig. 9.)

0. Spermagoniis epiphyllis, sparsis, in raris catervis in maculis pallidis, minutis, immersis, subflavis.

III. Soris teleutosporiferis amphigenis, praecipue hypophyllis, et caulicolis, in foliis raris, in maculis purpureis, sed saepe in incompositis catervis ad 40 mm. longis confertis, in caulis in catervis magnis, incompositis, detorsis, inflatisque ad 50 mm. longis, castaneo-brunneis, pulverulentibus. Teleutosporis ellipticis, non saepe subclavatis, 33–45 × 15–21 mmm.; apice rotundato, non v. leniter incrassato, basi subattenuato v. rotundato, cellulis similibus; ad septum constrictis; episporio minute reticulato, 1·5–2 mmm. crasso, fulvo, contentu vacuolato; pedicello deciduo, hyalino, breve, ad 60 × 7 mmm.; foramine germinis superioris cellulis apicale, conspicuo, foramine basali statim super pedicellum, conspicuo.

Hab.: In foliis vivis, petiolibus, surculisque *Hoheriae populneae* A. Cunn. Karori, Wellington, New Zealand. *R. Waters.*

13. **Puccinia inornata** sp. nov. (Fig. 36.)

0. Incognitis.

III. Soris teleutosporiferis amphigenis, caulicolisque, rotundis v. ellipticis, raris inde confluentibus, ad 1·5 mm. longis, cinnamomeis, pulverulentibus, epidermide rupta cinctis. Teleutosporis ellipticis, 23–35 × 12–16 mmm.; apice rotundato v. rustice acuminato, non incrassato, basi rotundato; cellulis similibus vel inferiore aliquantum angustiore; ad septum constrictis; episporio minute verrucoso, 1·5–2 mmm. crasso, pallido-brunneo; pedicello deciduo, hyalino, saepe tincto, breve, ad 20 × 5 mmm.; foramine germinis superioris cellulae apicale, conspicuo, saepe papillato, foramine basali statim super pedicellum, conspicuo.

Hab.: In foliis vivis, caulibusque *Cardaminidis heterophyllae* (Forst. f.) Schultz. Otago, New Zealand. *W. D. Reid.*

14. **Puccinia Kirkii** sp. nov. (Fig. 31.)

0, I. Incognitis.

II. Uredosoris amphigenis, raro hypophyllis, cinnamomeis, rotundis, raris, pulverulentibus, 0·5 mm. crassis, epidermide rupta cinctis. Uredosporis ellipticis v. obovatis, 23–29 × 19–21 mmm.; episporio raro rusticeque echinulato, 1–1·5 mmm. crasso, pallido-cinnamomeo, cum 3 raris foraminibus germinis.

III. Soris teleutosporiferis uredosoris immixis. Teleutosporis late ellipticis, 25–33 × 19–22 mmm.; apice rotundato, non incrassato, basi rotundato, raro attenuato, cellulis similibus; leniter constrictis ad septum; episporio leve, 1 mmm. crasso, pallido-brunneo, contentu granuloso; pedicello deciduo, hyalino, fragile, ad 33 × 5 mmm.; foramine germinis superioris cellulae apicale, conspicuo, foramine basali ⅔ infra septum, conspicuo, cellulis saepe papillatis.

X. Mesosporis raris, obovatis, 27 × 20 mmm.; apice rotundato.

Hab.: In foliis vivis *Rumicis neglecti* T. Kirk et *R. flexuosi* Sol. Otago, New Zealand. *E. H. Atkinson.*

15. Puccinia kopoti sp. nov. (Fig. 48.)

0. Spermagoniis amphigenis, sparsis, raris, subflavis.

I. Aecidiis hypophyllis, sparsis, raris, minutis. Peridiis cylindraceis, super superficiem exstitis, marginibus erectis, albis, laceratis. Aecidiosporis polygoniis, 18–24 mmm. crassis; episporio minute denseque verruculoso, hyalino, 2 mmm. crasso, contentu pallido-luteo.

II. Uredosoris hypophyllis, pallido-flavis, ellipticis, 1·5 mm. longis, raris, pulverulentibus, bullatis, epidermide in longitudinem diffindente. Uredosporis obovatis v. ellipticis, 25–35 × 16–20 mmm.; episporio rustice sparseque echinulato, 1·5–2 mmm. crasso, hyalino, contentu sulfureo, cum 3 raris foraminibus germinis.

III. Soris teleutosporiferis amphigenis, raris, rotundis v. ellipticis, 0·25–0·5 mm. latis, bullatis, pulverulentibus, spadicibus, diu tectis ad extremum rupta epidermide cinctis. Teleutosporis ellipticis v. saepe subclavatis, 30–40 × 18–22 mmm.; apice rotundato, vix incrassato necne, basi abrupte attenuato, saepe rotundato, cellula basali ferme angustiore quam superiorem; ad septum leniter constricto; episporio minute denseque verruculoso, 1·5–2 mmm. crasso, castaneo, contentu vacuolato; pedicello hyalino, deciduo, delicato, ad 45 × 5 mmm.; foramine germinis cellulae superioris apicale, conspicuo, foramine basali ½ infra septum, conspicuo, papillato.

Hab.: In foliis vivis petiolibusque *Anisotomidis aromaticae* Hook. f. Lake Harris, Otago, New Zealand. *W. D. Reid.*

16. Puccinia novae-zelandiae sp. nov. (Fig. 72.)

0. Spermagoniis epiphyllis, sparsis, raris, subflavis.

I. Aecidiis epiphyllis, in raris catervis in maculis decoloratis, rotundis, sparse confertis. Peridiis cylindraeceis, super superficiem folii 1 mm. exstitis, marginibus albis, revolutissimis, profunde incompositeque laciniatis, ad extremum genere *Roestelia* similibus. Aecidiosporis polygoniis, ellipticis v. obovatis, 25–35 × 15–22 mmm.; episporio minute denseque verruculoso, 1·5–2 mmm. crasso, hyalino, contentu flavo.

III. Soris teleutosporiferis hypophyllis, rubro-luteis, rotundis v. ellipticis, raris, pulverulentibusque, ad 0·5 mm. latis, in denso tomento folii profunde immersis. Teleutosporis ellipticis v. elliptico-clavatis, 55–93 × 25–37 mmm.; apice rotundato, non incrassato, basi rotundato, non saepe subattenuato, cellulis ferme similibus; ad septum constricto; episporio leve, 2–3 mmm. crasso, hyalino, contentu flavente, granuloso; pedicello persistente, hyalino, crasso ad 95 × 12 mmm.; foramine germinis cellulae superioris apicale, conspicuo, foramine basali statim infra septum, conspicuo.

X. Mesosporis vulgaribus, obovatis v. pyriformibus, 45–55 × 30–37 mmm.; apice rotundato, non incrassato, contentu flavente.

Hab.: In foliis vivis *Oleariae Forsteri* Hook. f. Pencarrow, Wellington, New Zealand. *E. H. Atkinson.*

17. Puccinia Oreomyrrhidis sp. nov. (Fig. 49.)

0. Spermagoniis amphigenis, raris, minutis, subflavis.

III. Soris teleutosporiferis amphigenis, praecipue hypophyllous, et caulicolis, primum raris, rotundis, minutis ad 0·5 mm. latis, et epidermide rupta cinctis, inde confluentibus, pulverulentibusque, ad extremum saepe tota infraficie folii tecta. Teleutosporis ellipticis, raro subclavatis, 31–45 × 17–20 mmm.; apice rotundato, paulum incrassato, 3–3·5 mmm., basi attenuato, cellula basali paulum longiore angustioreque quam superiorem; ad septum constricto; episporio minute sed clare punctato, 1·5–2 mmm. crasso, castaneo, contentu vacuolato; pedicello persistente, hyalino, fragile, ad 80 × 8 mmm.; foramine germinis cellulae superioris apicale, conspicuo, foramine basali $\frac{3}{4}$ infra septum, conspicuo.

X. Mesosporis raris, obovatis v. clavatis, aliquantum truncatis, 22–28 × 15–25 mmm.

Hab.: In foliis vivis *Oreomyrrhidis andicolae* Endl. Hanmer, Canterbury, New Zealand. *W. D. Reid.*

18. Puccinia pedatissima sp. nov. (Fig. 55.)

0. Incognitis.

III. Soris teleutosporiferis hypophyllis, minutis, 0·1–0·25 mm. latis, circularibus, in catervis raris, circularibus, ad 2 mm. latis, solide confertis, compactis, pulvinatis, nudis, ochraceis. Teleutosporis ellipticis, v. breve fusoideis. 40–52 × 14–18 mmm.; apice rustice acuminato, ad 8 mmm. crasso, basi attenuato, cellulis similibus v. cellula basali paullo angustiore, contentu granuloso, nucleis conspicuis; ad septum leniter v. non constrictis; episporio leve, 1–1·5 mmm. crasso, brunneo tincto; pedicello persistente, hyalino, ad 40 × 6 mmm., sporo se inclinato; foramine germinis cellulae superioris apicale, obscuro, foramine basali statim infra septum, obscuro.

X. Mesosporis raris, 25–30 × 12–16 mmm., apice acuminato, incrassatoque.

Hab.: In foliis vivis, petiolibusque *Ourisiae macrophyllae* Hook. Mount Egmont, 1,200 m,, New Zealand. *W. D. Reid, N. R. Foy.*

19. Puccinia pounamu sp. nov. (Fig. 74.)

0. Spermagoniis hypophyllis, sparsis, raris, immersis, subflavis.

III. Soris teleutosporiferis amphigenis, praecipue hypophyllis, in raris catervis in maculis decoloratis, cinctis marginibus flavis confertis, rotundis, minutis, 0·5 mm. latis, pulvinatis, compactis, castaneis, epidermide rupta cinctis. Teleutosporis elliptico-clavatis v. ellipticis 47–65 × 14–29 mmm.; apice rotundato, raro rustice acuminato, incrassato ad 10 mmm., basi attenuato, cellula inferiore angustiore et aliquantum longiore quam superiore; ad septum leniter constricto necne; episporio leve, brunneo fere hyalino, 2–2·5 mmm. crasso; pedicello persistente, hyalino, crasso ad 50 × 12 mmm.; foramine germinis cellulae superioris apicale, obscuro, foramine basali statim infra septum, obscuro.

Hab.: In foliis vivis *Senecionis southlandici* Cockayne. Otago, New Zealand. *W. D. Reid.*

20. Puccinia Reidii sp. nov. (Fig. 37.)

0. Spermagoniis amphigenis, soros praecessis, in maculis decoloratis, raris v. in raris catervis, immersis, subflavis.

III. Soris teleutosporiferis amphigenis, caulicolisque, ellipticis, raris, ad 1 cm. longis, bullatis, pulverulentibus, nigris, diu tectis ad extremum expositis rupta epidermide. Teleutosporis elliptico-ovatis, 32–42 × 15–22 mmm.; apice rotundato, raro acuminato, non incrassato, basi rotundato, cellulis similibus, contentu granuloso; ad septum constrictis; episporio castaneo, clare striato, striis ad axes se inclinatis, crasso 3 mmm.; pedicello deciduo, hyalino, ad 45 × 6 mmm.; foramine germinis superioris cellulae apicale vel saepe ¼ infra summum, conspicuo, foramine basali statim infra septum, conspicuo, cellulis ferme papillatis.

Hab.: In foliis, petiolibus, caulibusque *Radiculae* sp. ined. Otago, New Zealand. *W. D. Reid.*

21. Puccinia tararua sp. nov. (Fig. 52.)

0. Spermagoniis amphigenis, sparsis, raris, immersis, subflavis.

II. Uredosoris amphigenis, caulicolisque, raris v. in incompositis catervis confertis, ad 2 mm. latis, rotundis, pulverulentibus, cinnamomeis, rupta epidermide cinctis. Uredosporis obovatis v. subglobosis, 20–30 × 18–23 mmm.; episporio rustice sparseque echinulato, crasso 1 mmm., pallido-flavo, cum uno foramine germinis conspicuo.

III. Soris teleutosporiferis amphigenis, caulicolisque, raris, rotundis, ad 1 mm. latis, castaneis, pulvinatis, compactis, rupta epidermide cinctis. Teleutosporis fusiformibus, 50–70 × 10–15 mmm.; apice rustice acuminato v. rotundato, incrassato ad 10 mmm., basi attenuato, ad pedicellum leniter se inclinato, cellulis similibus: leniter ad septum constricto necne; episporio leve, 1 mmm. crasso, pallido-brunneo v. ochraceo, contentu vacuolato; pedicello persistente, hyalino, crasso ad 50 × 10 mmm.; foramine germinis cellulae superioris apicale, obscuro, foramine basali statim infra septum, obscuro.

Hab.: In foliis vivis, caulibusque *Gentianae patulae* Cheesem. Mount Hector, Wellington, New Zealand. *E. H. Atkinson.*

22. Puccinia tiritea sp. nov. (Fig. 32.)

0. Spermagoniis epiphyllis, in catervis raris subrotundis, in maculis flavis, minutis, immersis, subflavis.

II. Uredosoris hypophyllis, raris vel in catervis incompositis, non confluentibus, rotundis v. ellipticis, minutis, 0·25–0·5 mm. latis, pulverulentibus, cinnamomeis, epidermide rupta cinctis. Uredosporis obovatis, 25–32 × 22–28 mmm.; episporio raro rusticeque echinulato, 1·5–2 mmm. crasso, cinnamomeo, cum 2–3 raris foraminibus germinis.

III. Soris teleutosporiferis uredosoris similibus immixisque, spadicibus. Teleutosporis late ellipticis, 25–32 × 17–25 mmm.; apice rotundato, non incrassato, basi rotundato, raro attenuato, cellulis similibus: episporio rustice verrucoso, 1·5–2 mmm. crasso, castaneo; pedicello deciduo, hyalino, breve, ad 30 × 7 mmm.; foramine germinis superioris cellulae statim super septum, conspicuo, foramine basali statim infra septum, conspicuo.

Hab.: In foliis vivis *Muehlenbeckiae australis* (Forst. f.) Meissn. et *M. complexae* (A. Cunn.) Meissn. Palmerston North, Wellington, New Zealand. *G. H. C.*

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COMBINED HOST AND FUNGUS INDEX.

All synonyms are in italics. Page numbers of synonyms and of incidental references are in ordinary type; those under which are to be found descriptions of species, genera, or families, or hosts of these species, are in italics; those under which are to be found Latin diagnoses of new species are in brackets. An asterisk preceding a page number indicates that an illustration of the species in question will be found on that page.

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DESCRIPTION OF PLATE 77.

FIG. 1.—*Uromyces Discariae* sp. nov. Cylindrical aecidia from *Discaria toumatou* Raoul. × 2·5.

FIG. 2.—*Aecidium otagense* Lindsay. Showing distortion of the host, *Clematis indivisa* Willd., caused by the perennial mycelium. Half nat. size.

FIG. 3.—*Uromyces Betae* Lev. Bullate uredo- and teleuto-sori, on *Beta vulgaris* L. The white outline round the sorus is the ruptured epidermis. × 2·5.

FIG. 4.—*Puccinia graminis* Pers. Linear naked teleutosori on *Triticum vulgare* Vill. × 2·5.

FIG. 5.—*Puccinia clavata* Syd. Cylindrical erumpent aecidia surrounding the immersed spermogones: on *Clematis hexasepala* DC. × 2·5.

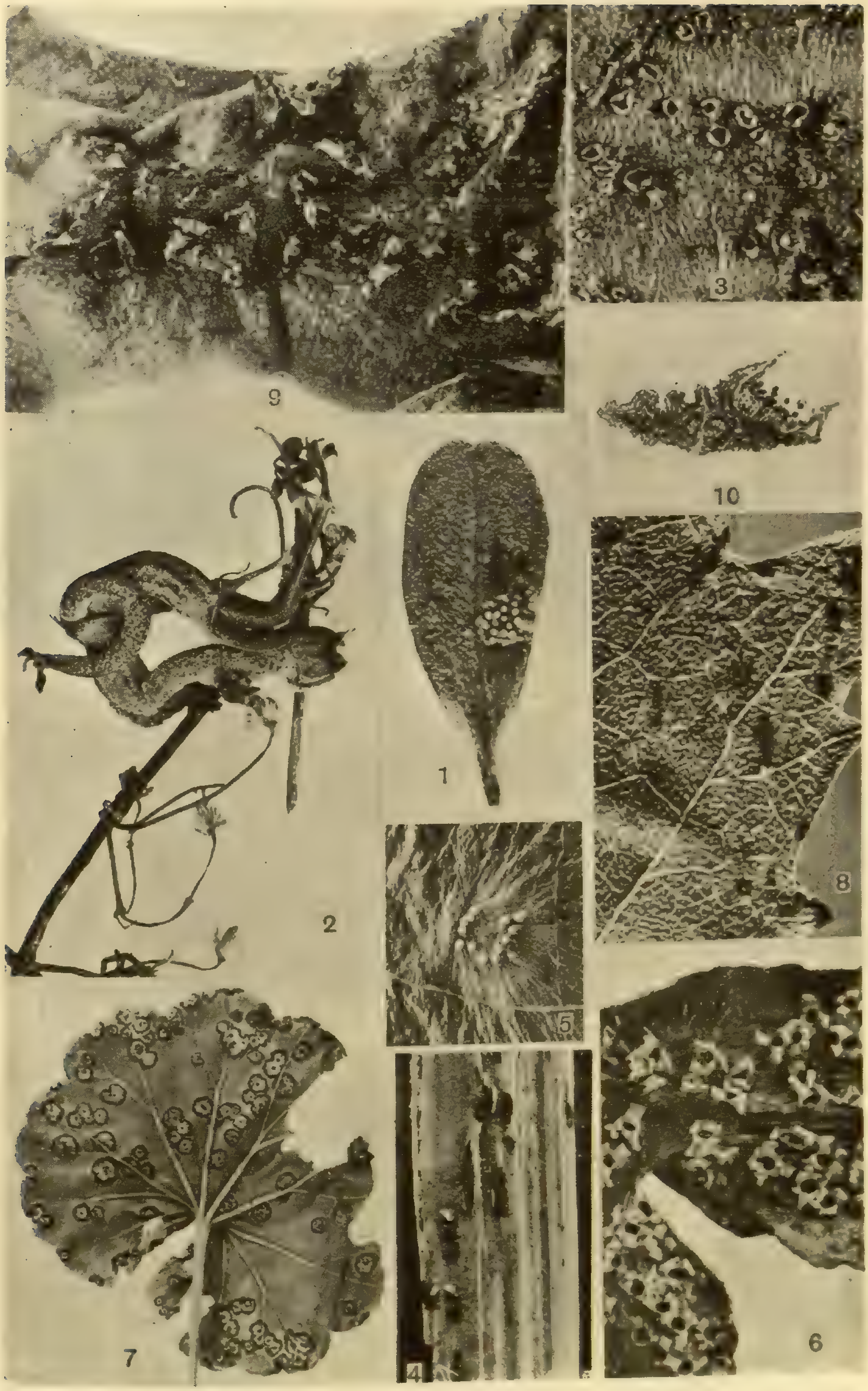
FIG. 6.—*Puccinia Pruni-spinosae* Pers. Widely expanded aecidia on *Anemone*. × 2·5.

FIG. 7.—*Puccinia granularis* Kalch. et Cke. Circinnate teleutosori surrounding the bullate uredosori; on *Pelargonium zonale* L'Her t. Half nat. size.

FIG. 8.—*Puccinia Plagianthi* McAlp. Scattered, circular teleutosori on *Plagianthus betulinus* A. Cunn. × 2·5.

FIG. 9.—*Puccinia Hoheriae* sp. nov. Confluent pulverulent teleutosori on *Hoheria populnea* A. Cunn. Note leaf-distortion. × 2·5.

FIG. 10.—*Puccinia Hydrocotyles* Cke. Aecidia on *Hydrocotyle novae-zelandiae* DC. Microphotograph of a section. × 30.



[Photos by E. Bruce Levy.

Art. 45.—*Maori Plaited Basketry and Plaitwork: I, Mats, Baskets, and Burden-carriers.*

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Plates 78–82.

Introductory.

We owe a duty to the Maori race to gather and put on record such remnants of information of their ancient arts and crafts as still survive the deluge of civilization. To Hamilton, Brigham, and others we owe much for the illustrations and general description in their works, but more data as to technique is required to supplement their labours. For the comparative study of the Polynesians and their neighbours, the technique used in the beginning, finish, and strokes used in the body of the articles must supply valuable information and be of high scientific importance. From a sentimental point of view, it may interest future generations of the ultimate mixed race of New Zealand to look up the methods and doings of their Maori ancestors. From an economic standpoint, Maori baskets and mats are so easy to make, and the material so accessible and inexpensive, that dwellers remote from towns, and campers by coast and forest, might well derive benefit from the study of the technique of the Maori art of plaiting.

The data from which this article is compiled was gathered from the Ngati-Pamoana subtribe of the Whanganui Tribe, who dwell at Koriniti and Operiki, on the Whanganui River. It was originally intended to make it the basis of a comprehensive article on basketry and plaiting throughout New Zealand. So many variations occur amongst the different tribes, however, that it was considered advisable to postpone their consideration until more exhaustive inquiries have been made. The variation in names and types is shown by the fact that Williams's Maori Dictionary contains over seventy names for kinds of baskets alone.

Basketry and matting are made amongst the Maoris by hand from strips of unspun material. The small baskets with coloured designs, made from prepared flax-fibre twisted on the thigh into warp elements, are a modern innovation, derived from the art of weaving cloaks, and do not belong to this article. "Basketry," to quote from *Notes and Queries on Anthropology*, "may be *woven* (where there are two elements), or *plaited* (where all the elements start and end parallel, sometimes confused with weaving), or *coiled*." Following the classification adopted by the Bureau of American Ethnology, basketry is divided into checker-work, twilled work, wicker-work, wrapped work, and twined work. Wicker, wrapped, and twined work are done on stiffer material, and may be seen in the various fish-traps for eels and *inanga* (adult of *Galaxias attenuatus* and fry of *G. brevipinnis*). They are not dealt with here. Coiled basketry, which is really sewing, is done by sewing or whipping together, in a flat or ascending coil, a continuous foundation of rod, splint, shredded fibre, or grass, or by interlocking stitches without foundation. This class of work was not done by the Maori.

The scope of this paper is thus confined to plaited basketry of the checker and twilled types; but as other articles besides baskets and mats are plaited from similar material and with the same strokes, the following will come into review: (1) Mats; (2) baskets; (3) burden-carriers, or *kawe;* (4) belts and bands; (5) fans and fly-flaps; (6) sails; (7) sandals; and (8) ropes and cords.

Plaiting.

Plaiting, whether checker or twilled, is included under the general term *raranga,* but the plaiting of ropes and cords is termed *whiri.*

Survival of Plaiting.—The rougher baskets and mats, being in everyday use, are still made throughout the country. European plates and dishes have done away with the need for the rough flax containers for cooked food, and many of the younger generation of Maori have never even seen them, so naturally know nothing of how to plait them. The art of making the finer mats and baskets, with coloured designs, is rapidly passing away, and is now confined to the old and middle-aged in certain districts. Burden-carriers, or *kawe,* whilst still in use in the Whanganui and North Island west-coast districts, are now unknown over the greater part of the country. Plaited belts, fire-fans and fly-flaps have practically disappeared. Sandals, even in the old days, had only a limited geographical distribution, and the advent of boots and shoes has long since relegated them to oblivion. Of sails, we know of only one in existence, which is in the British Museum. Ropes are still plaited by a few of the older generation of men.

Definition of Terms.

The vocabulary of basketry has been so varied and confusing that it is necessary to define the terms used. These are adopted from those used by Mrs. A. H. Quiggin.

Weft: A technical factor in plaited basketry. A weft may consist of a single strip of material or a number of strips. The confusion between warp and weft in plaiting is obviated by terming the strips which lean towards the right *dextral* wefts and those towards the left *sinistral.*

Braid: Synonymous with *plait.*

Check, or *checker:* Each weft passes alternately over and under each consecutive crossing weft.

Cord: Two or more wefts twisted together in the same direction.

Decoration: The addition of elements, not essential to the construction, for the purpose of ornament.

Design: The general effect derived from the pattern or conjunction of patterns.

Overlaid weaving, plaiting, &c.: Wefts not essential to the construction, inserted for decorative purposes.

Patterns: The surface effects produced by various strokes.

Plait: The regular interlacing of not less than three wefts to form a continuous band or surface. A plait, cord, or twine is described as three-ply, four-ply, &c., according to the number of wefts.

Stroke: A completed movement in plaited basketwork corresponding to stitch in needlework.

Three-ply plait, cord, &c.: See *Plait.*

Twilled twos, threes, &c.: Each weft passes over or under two, three, &c., crossing wefts.

Otis Mason defines a strip as follows:—

"*Strip:* A narrow ribbon of leaf or other thin basket-material, answering in function to the harder splints."

PLANTS USED.

In plaiting it is in almost all cases the leaves of the plants that are used, and the plants selected are therefore those with long leaves to provide suitable wefts. In one case the stem is used, and in another the bark. For the description of the parts of the plants used we have quoted freely from Cheeseman's *Manual of the New Zealand Flora.*

Phormium tenax (New Zealand Flax; *Harakeke*).—Flax forms the chief material used in all forms of plaiting and weaving. It grows abundantly throughout both Islands, especially in lowland swamps and alluvial ground. Up the Whanganui River it was introduced and cultivated, so that each village had its *pa harakeke*, or flax-garden. Even in villages close to flax swamps, flax was grown close to the houses for immediate use. The Maori recognize several varieties with different quality of leaf and different strength of fibre. The famous *katiraukawa*, whose fibre was so sought after for weaving, is too thick and strong in the leaf for baskets and mats. Whilst it can be so used, other varieties with less fibre and a softer blade are preferred.

The leaves grow from 3 ft. to 9 ft. long or more, and the blades are 2 in. to 5 in. wide, keeled, and the margins and midrib bordered with a red or orange line. The upper or inner surface (*aroaro*) is dark green, and the lower or outer (*tuara*) of a paler sea-green colour. When dry the two surfaces maintain their difference in colour, the upper being brighter and having a smoother appearance. At a point somewhere about midway from the tip the two inner surfaces of the two halves of the blade begin to coalesce at the midrib, and this coalescence gradually increases until one-half of the leaf is joined together and the remainder in close opposition. The Maoris called the part above the diagonal line of coalescence the *kauru*, or leaf, and the part below they called the *putake*, or butt. For ease of description, later on we shall refer to the line of coalescence of the two half-blades as the "butt-junction."

Phormium Cookianum (Wharariki).—This species is much smaller than *P. tenax*. It contains little fibre, and is softer and is less rigid. The leaves are 2 ft. to 5 ft. long, 1 in. to 2½ in. broad, pale green, seldom glaucous, and the margins and midrib seldom bordered with a coloured line. It grows throughout the North Island, and was the only original species growing up the Whanganui, where it grew plantifully about the cliffs and steep slopes of the river. On account of its softness and ease of manipulation it was considered by the Whanganui people to be the best material for plaiting purposes, though the fibre was useless for weaving. Some tribes, such as the Nga-Rauru, of south Taranaki, where *Phormium tenax* is abundant, have imported it to their district, where it is cultivated for plaiting baskets, mats, and burden-carriers.

Freycinetia Banksii (Kiekie).—The Maori was acquainted with *Freycinetia* in the Pacific islands, where those branches of the Polynesians who drop the *k* sound in their speech call it *ieie*. Both there and here the fine roots are used in twined weaving; but with the Maori the leaves are largely used for the best class of mats, baskets, and belts. The *kiekie* grows abundantly throughout the North Island and parts of the South, where it climbs up forest-trees or scrambles over rock and prostrate tree-trunks. The leaves are numerous towards the tips of the branches. They are long and narrow (1½ ft. to 3 ft. long, ½ in. to 1 in. broad), sharply pointed, with a broad sheath at the base, concave, tough, leathery, and with the margins and midrib serrated with sharp spines. The leaves are used in making rough rain-cloaks.

Scirpus frondosus (Pingao).—The *pingao* grows abundantly on the sand-dunes near the coast throughout both Islands. It grows 2 ft. to 3 ft. high, and is of a yellow-green colour. The leaves are very numerous, often curved, very tough and leathery, channelled above, keeled below, gradually narrowed into long points, and expanded at the base into broad membranous sheaths. The margins and midrib are finely toothed. When dry the leaves have a yellow-orange colour, and are used in the colour-designs in fine mats, baskets, and belts. Inland tribes imported the prepared material from their coastal friends. The *pingao* was also used in the lattice-work panels of houses to give colour to the *tukutuku* patterns.

Scirpus lacustris (Paopao, or *Kutakuta).*—The *paopao* grows in the margins of lakes and swamps or ponds. The stems are 2 ft. to 6 ft. high, sometimes almost as thick as the finger, cylindrical, spongy, leafless, and sea-green in colour. The stems are used in the plaiting of floor-mats.

Cordyline australis (Cabbage-tree ; *Ti-kouka,* or *Whanake*).—The *ti-kouka* is abundant throughout both Islands, and reaches a height of from 15 ft. to 40 ft. The leaves form a dense round head at the top of the stems or branches. They are from 1½ ft. to 3 ft. long, 1½ in. to 2½ in. broad, flat, firm, sea-green, sword-shaped, sharp-tipped, slightly contracted just above the broad sheathing base, and have an indistinct midrib. The fibre in the leaf is strong and durable. The whole leaf is plaited into ropes and baskets, and their wefts are used for a neat basket, which is usually dyed black. Sandals were also made from the full leaf.

Cordyline indivisa (Toi).—The *toi,* the finest species of the Cordylines, grows in mountain districts in both Islands. The stem is stout, erect, rarely branched, and grows from 5 ft. to 25 ft. in height. The leaves are very numerous, spreading all round and forming a massive head. They are 2 ft. to 6 ft. long, 4 in. to 6 in. broad at the middle, broadly sword-shaped, tapering to a sharp point at the tip, usually contracted below and then expanded at the sheathing base. They are thick, tough, leathery, flat, greenish with faint purplish or reddish tint above and sea-green beneath. The midrib is very thick and prominent below but gradually decreases upwards. The lateral veins are very numerous and strong. The midrib, on account of its red or yellowish-red colour, is used sometimes in baskets. The fibre of the *toi* is very strong. Whilst its most common use is in the manufacture of a fine type of rain-cloak, it may on occasion be used in plaiting.

The other species of *Cordyline*—*C. terminalis (ti-pore), C. Banksii (ti-ngahere),* and *C. pumilio (ti-rauriki)*—probably had their leaves used on occasion for the same purposes as *C. australis.*

Astelia Cunninghamii (Wharawhara, Kowharawhara).—This species is abundant throughout the woods of the North Island and part of the South. It is densely tufted, and grows on the ground or is epiphytic on trees. The leaves are numerous, 2 ft. to 5 ft. long, ½ in. to 1 in. broad at the middle, drawn out to a point, contracted below and widening out at the sheathing base. They are rigid, thick, leathery, and with silky midrib and margins, the latter being recurved. The leaves were used by sojourners in the forest for temporary baskets for food, or even as mats to cover the food whilst cooking in the *umu,* or oven.

Astelia Banksii (Wharawhara, Kowharawhara, Puwharawhara).—This species has a longer and broader leaf than *Astelia Cunninghamii,* 2 ft. to 6 ft. long and ½ in. to 1½ in. broad. It has not such a wide distribution, being limited to the North Island as far south as Hawke's Bay and Taranaki, and

growing usually near the coast. The leaves are used for the same purpose as those of the previous species; and, though this one does not come within the region of the Whanganui people, owing to similar Maori names being used it is included here for completeness. There is no doubt that other species of *Astelia* would be used for temporary purposes where more suitable material was lacking.

Rhopalostylis sapida (New Zealand Palm; *Nikau*).—The *nikau* is abundant throughout the North Island forests, and is found in parts of the South Island. The stem grows from 10 ft. to 25 ft. high. The leaves grow in a terminal crown, are pinnately divided, and are from 4 ft. to 8 ft. long. The midrib is stout and the leaflets very numerous, 2 ft. to 3 ft. long or more, and 1 in. to 2 in. broad. The most primitive kind of basket was made from the leaf, similar to those made in the Pacific from the leaf of the coconut-palm.

Hierochloe redolens (Karetu).—The *karetu* is an erect sweet-scented grass, which grew abundantly in moist places throughout both Islands, but has become scarce in many parts owing to cattle and stock. The leaves are numerous, from $1\frac{1}{2}$ ft. to about 3 ft. in length, and $\frac{1}{4}$ in. to $\frac{1}{2}$ in. in breadth. They are flat, smooth, deeply striate, and a bright shining green. The leaves were used in making belts.

Carex lucida and *Carex comans (Maurea)*.—These perennial herbs are found in both Islands, and are both called *maurea* by the Maori. *C. lucida* has numerous leaves, spreading or drooping at the tips, narrow ($\frac{1}{15}$ in. to $\frac{1}{8}$ in. broad), keeled, and with margins and keel slightly rough. The length of leaf is up to 2 ft. *C. comans* has shorter and narrower leaves, 18 in. long and $\frac{1}{30}$ in. to $\frac{1}{15}$ in. broad. They are flat and concave in front, slightly rounded at the back, grooved and striate, with slightly rough edges. *Maurea* leaves when dry have a reddish-yellow colour, and are used in women's belts.

Hoheria populnea (Ribbonwood, or Lacebark; *Houhi*, *Whauwhi*, *Houhere*).—The *houhi* is a tree 10 ft. to 30 ft. high, growing in both Islands. The inner bark splits readily into strips, which are used in plaiting baskets, bands, kilts, &c.

PREPARATION OF MATERIAL.

Owing to the nature of the material, the Maori were saved much preliminary labour that is entailed where bark, wood, and roots are used. For dividing the leaves into strips and otherwise preparing them the only implement necessary was a shell. The shells used were those of the sea-mussel, *kuku* (*Mytilus edulis*); the fresh-water mussel, *kakahi* (*Diplodon lutulentus*); and the mutton-fish, *paua* (*Haliotis*). Taking the preparation of the *Phormium tenax* as typical, the processes of preparing the strips differed according to the kind of weft required. The kinds of wefts used were (1) natural wefts, (2) white wefts, and (3) dyed wefts.

(1.) *Natural Wefts*.—By "natural" wefts we mean that, beyond splitting the leaf into strips and getting them ready for plaiting, nothing was done to alter the natural appearance of the material. In preparing these natural wefts from a blade of flax, three stages were recognized: (*a*) splitting the blade into even strips; (*b*) removal of the strips from the butt; and (*c*) scraping the butt ends of the strips. With a sufficient number of blades to complete the task, the craftswoman completed each stage before passing on to the next.

(*a*.) Splitting the blade into strips (*toetoe*): The margins and midrib of the leaf, with the red or orange line bordering them, were first split off with

the thumb-nail. This waste material was termed *kaikaha*. The two half-blades, freed by the removal of the midrib, were held together with the left hand whilst the right thumb-nail split them into even widths, of ⅜ in. to ¼ in. for baskets, and somewhat wider for mats. As the thumb-nail worked across the blade from right to left the right forefinger and middle finger followed through the openings made and separated the alternate divisions. Holding the butt end of the blade with the left hand, the right fingers were simply drawn along the blade to the tip and completely separated all the divisions. Holding the mid-part of the blade with the freed right hand, the fingers of the left hand were slipped between the divisions and ran them down to the butt-junction. As each blade was dealt with it was laid down neatly on the left of the worker with the butt end towards her. Wonderful accuracy was displayed in maintaining the even widths of the strips throughout. At Koriniti, during a display of plaiting by the older women, some girls joined in preparing the strips. Later on, whilst plaiting the baskets, the women expressed great disgust at the uneven strips preventing neat work, and took it as a sign that the art of plaiting would soon die out.

(*b*.) Removal of the strips from the butt (*takirikiri*): The object here is not only completely to separate the strips, but to remove as little of the butt with them as possible. Owing to the flax of the butt being thicker, stiffer, and narrower, its inclusion in the strip would result in uneven wefts, and cause harder work in manipulating them. The butt near the butt-junction was clasped firmly in the left hand, fingers at the back, thumb in front. The strips are in two rows, one above the other, corresponding to the two half-blades. The right upper strip was seized with the right hand and bent back along the line of the butt; the left thumb was pressed firmly on its junction with the butt, and creased it transversely. Keeping the firm pressure of palm and thumb, the strip was torn off with a quick, sharp pull of the right hand. The right lower strip was then turned back, creased and held against the butt by the left forefinger, and torn off. The remaining strips were treated in a similar way, working from the right and taking the upper and lower strips in turn. It is the quick, sharp pull that gives the name of *takirikiri* to this stage. Each removed strip has a tuft of fibre at the end which was torn from the butt. The strips were kept in the right hand until the blade had been finished, when the separated butt was cast aside and the strips laid down in a neat heap with the tufted ends towards the worker. The secret of this simple process consists in keeping the blade held tightly and pressing down firmly on the strip-junction. If held loosely the strip will run out to the end of the butt. My first efforts were the cause of much amusement to my instructresses.

(*c*.) Scraping the butt ends of the strips (*kaku*): Each strip was taken individually, and the tuft of fibre at the butt end scraped with one of the kinds of shell mentioned above, to remove the non-fibrous material, or *tutae*. It will thus be realized that one of the objects in doing the previous stage neatly is to leave as little scraping as possible to be done in this stage. Where too much butt has been removed, extra time and work are involved in scraping it off. The shell is held with its outer surface towards the body, and, in scraping, the movement of the hand with the shell is away from the body. The scraping of the ends in this manner to remove the epidermis and interfibrous matter gives the exact meaning of *kaku*. The scraped tuft of fibre will be referred to as the "butt-tuft."

The strips having been treated in this way are ready for plaiting into the ordinary mats and baskets for common use. When they become dry they become stiffer, and the colour changes to brown. The two surfaces have a different shade, whilst that corresponding to the anterior (or inner) surface of the leaf maintains its smoother appearance.

(2.) *White Wefts.*—The term " white wefts " is used because the natural wefts are put through a further process to render them as white as possible. Here again the process may be divided into three stages, as follows :—

(*a.*) Treatment with hot water : In these days the rough wefts are boiled for a few minutes in a large pot or a kerosene-tin. In olden days the water was heated in a wooden vessel (*kumete*) by dropping in red-hot stones. The heat softens the strips and helps to get rid of the green colouring-matter in the leaf.

(*b.*) Light scraping (*piahu*) : On removal from the hot water the strips are scraped along their whole length on both sides. Shells were used, but blunt knives are now more in favour. The scraping is done lightly, so as not to cut down on the fibre. A certain amount of epidermis and colouring-matter is removed, and the strips rendered softer and more pliable. The light scraping is accomplished by drawing the strip with the left hand back towards the body against the lower edge of the shell. The term *piahu* as sometimes loosely applied to the *kaku* process is incorrect. As each strip is done it is laid down on a heap with the butt-tuft towards the worker.

(*c.*) Drying (*whakamaroke*) : The scraped strips are gathered up in small bundles, the tufted ends are tied together, and the bundles straddled over a line to dry. When dry they assume a whiter appearance. The surface corresponding to the anterior surface in the leaf has a whiter colour than the back, and maintains its smoother appearance. They are softer and easier to manipulate than the rough wefts. *Kiekie* strips are treated in this manner, and become whiter than flax. The bundles of white wefts, when dry, are often beaten against the ground or a stone to render them softer and more pliable.

For the best class of floor-mats the butt-tufts were not necessary. In preparing the wefts for them the *takirikiri* and *kaku* stages of the rough weft were omitted. After slitting the leaf down to the butt-junction the butt was cut off short, leaving a short piece of undivided butt linking the divisions of a half-blade together. In some cases, perhaps two or four strips were left united. These were then boiled, lightly scraped, and dried, and became white wefts without butt-tufts.

White wefts were used in plaiting the better class of floor-mats and baskets, burden-carriers, and some varieties of belts.

(3.) *Dyed Wefts.*—The dyeing process is continued on from the last. Though red, yellow, and black dyes are used with prepared fibre for weaving cloaks, so far as I know black was the only dye used originally in plaiting. Colenso, however, mentions that a blue-black, obtained from the bark of the *tutu* (*Coriaria ruscifolia*), was used in graceful little baskets for a beloved child. Yellow was obtained from the natural colour of the *pingao* (*Scirpus frondosus*). In these degenerate days European dyes of any shade are used. The stages in dyeing are as follows :—

(*a.*) Treatment with a mordant (*waitumu*) : A mordant to fix the dye was prepared from the bark of the *hinau* (*Eleocarpus dentatus*). The bark was pounded on a flat stone with a beater and mixed with cold water in a wooden bowl (*kumete*). The white wefts were soaked in this infusion for about twelve hours and then hung up to dry. Besides *hinau*, the leaves

of the *tutu* were used as an infusion. On drying, the strips were much darkened in colour.

(*b.*) Black dye (*parapara*): The black colour is obtained by treating the dried strips with the black mud (*parapara*) from peaty swamps. The strips may be rubbed with the mud or, what is more usual, the material is pushed down into the mud in the swamp and left there for eight or ten hours. On removal the wefts have assumed a deep-black colour which is very fast. The best mud is in those swamps where a red rust is collected from the surface for obtaining the red ochre so much prized by the ancient Maori for decorative purposes. If the infusion is poured on the mud it turns an intense black, like ink. It is therefore probable that the black colour is caused by a chemical combination between the tannic acid in the mordant and an iron salt in the mud. It is interesting here to note that the Samoans obtained a black colour by burying the articles in the soft mud of a *taro* patch formed in a swamp. Without the mordant the black colour of Maori articles soon faded. The strips on removal from the mud were washed and dried.

The dyed wefts were used in the coloured designs in mats, baskets, and belts. The neat baskets made from the *Cordyline australis* were often dyed black by putting the completed basket into the mud.

Scirpus lacustris (Paopao, or *Kutakuta).*—The full-grown stems of new growth immediately after cutting are spread out and covered with old mats. The cylindrical stems are thus flattened out, *pararahi*. They are usually left covered for three days, but are frequently inspected and turned so as to obtain an even shade of colour. They turn brownish-red. They are then hung up to dry, and when quite dry are plaited into floor-mats. This material is softer than flax or *kiekie.*

Manufacture of Material.

The prepared strips of material as they are being plaited into articles are termed "wefts." My experience in seeking for the Whanganui word for "weft" is interesting, and instructive in view of the difficulties that must beset the ethnologist seeking for information in an unknown or little-known language. In my case, Maori is my mother-tongue. I picked up a strip of flax (*harakeke*), and in our own mutual language asked my instructress, "What is the name of this?" "*Harakeke,*" she replied. "Yes," I said, "it is *harakeke*, flax. When the plant is growing it is *harakeke;* when a blade is cut from the bush it is *harakeke;* but when you have split the blade into narrow widths, stripped the widths from the butt and scraped the butt-ends, what is the strip?" "*Harakeke,*" she replied. "Quite so," I said, "the material is still *harakeke;* but is there no name to distinguish between the prepared strip and the full blade of flax?" "No," she replied, "it is *harakeke.*" "Let us suppose," I said, "that you wanted me to pass you some of these strips to plait a mat, what would you say?" "Pass me that *harakeke,*" she replied patiently. "Let us suppose that you are instructing me in plaiting a mat. We have started off with a check pattern and you now want me to change to a twilled two. You tell me, instead of picking up alternate ones with the left hand, to pick up alternate twos. Two what?" I asked triumphantly. "Two *harakeke,*" she replied serenely. "Then," I said disappointedly, "there is no special word?" "No," she said convincingly, "they are just *harakeke.*" I turned to a European friend and said in English, "We can note down that the Whanganui Tribe has no special word for 'weft.'" In the evening

the same lady was instructing me how to finish off the top border of a mat. I had found, as others have found, that plaiting cannot be properly described unless one actually learns how to do it. In the finishing process, on turning back the wrong weft, my instructress called out, "No, not that one; turn back the left *whenu.*" "The left what?" I asked. "The left *whenu,*" she replied without hesitation. "What is a *whenu?*" I asked with suppressed excitement. "A *whenu,*" she explained placidly, "is a strip of *harakeke* used in plaiting." "I thought," I remarked, "that the *whenu* is the warp used in weaving." "So it is," she said; "the warp of dressed fibre used in weaving cloaks and the strip of *harakeke* used in plaiting mats and baskets are both called *whenu.*" "Are you sure?" I asked. She turned her tattooed face towards me with an indulgent smile and gently replied, "Have I not said it? Do you doubt my word?" "No," I hastened to say, "but two hours ago you told me there was no such word." "Ah," she said, with the faintest tinge of embarrassment in her smile, "we think so much about European matters in these days that the old Maori words sometimes elude us for the moment. The strip of prepared *harakeke* is called *whenu.*" I turned to my European friend and said, "We will cross out our previous note, and write instead thereof, 'The Whanganui Tribe *has* a special word for weft, and it is *whenu.*'"

The methods of beginning and finishing will be described under the various articles.

The strokes used come under the headings of checker-work and twilled work.

Checker-work, as defined, consists in each weft passing alternately over and under each consecutive crossing weft. This plait is termed *takitahi* (singly). When the butt ends of the wefts have been fixed in a straight line the wefts lie parallel to one another. Adjacent wefts are now crossed diagonally over each other so that alternate wefts lie in the same direction. Those leaning towards the right are called "dextral" wefts, and those towards the left "sinistral." The plaiting of the wefts is not done singly, but in a series. Alternate dextral wefts are lifted up with the left hand, and the right hand picks up and slips the appropriate sinistral weft along the space between the dextral wefts that are held up and those that are lying flat. The dextral wefts that were lifted up are now dropped and those that were lying flat are picked up in their turn. The next sinistral weft is now passed between. In this way a series of alternate dextral wefts pass above one sinistral and then below the next, whilst the series of alternate dextrals that passed below the first sinistral now passes above the second. This results in checker-work as defined above. The process may be compared to weaving. The dextral wefts correspond to the warps, which are separated in series of alternate threads, whilst the sinistral weft corresponds to the weaving weft which passes through on the bobbin. In weaving, however, the weft works across parallel to the straight edge lying transversely in front of the weaver. In plaiting, whilst the straight edge of a mat, for example, lies transversely in front of the plaiter, the wefts lie diagonally. To meet this the plaiter commences her work on the left. In fig. 1 the dextral wefts are shown plain and lettered D, whilst the sinistrals are shaded and lettered S. The dextrals are crossed over the sinistrals at the beginning, and this initial crossing is not counted in the following description. The first sinistral after passing under the first dextral is bent back into the body of the mat and becomes a dextral. This bend, being vertically above the end of the mat, is the commencement of the left border of the mat.

Sinistral 2, after passing under dextral 2, passes between two dextrals and, coming into the vertical line of the left border, is bent back into the body to become a dextral. S3 passes between four dextrals and S4 between six before being turned back. S5 passes between eight dextrals, and, this being a usual width for plaiting, it is not necessary to turn it back for the present. Working with eight dextrals, picking up four and dropping four, the plaiter works towards the right across the article with the diagonal edge shown. As each sinistral weft is placed between the alternating fours, a fresh dextral is picked up below and the top dextral of the previous series left out. Thus she keeps to the eight dextrals throughout the width of the article, and the last row plaited is parallel with the lower edge of the mat. When the right edge of the article is reached, the dextral wefts which project beyond it are turned back into the body of the mat, as on the left, and become sinistrals.

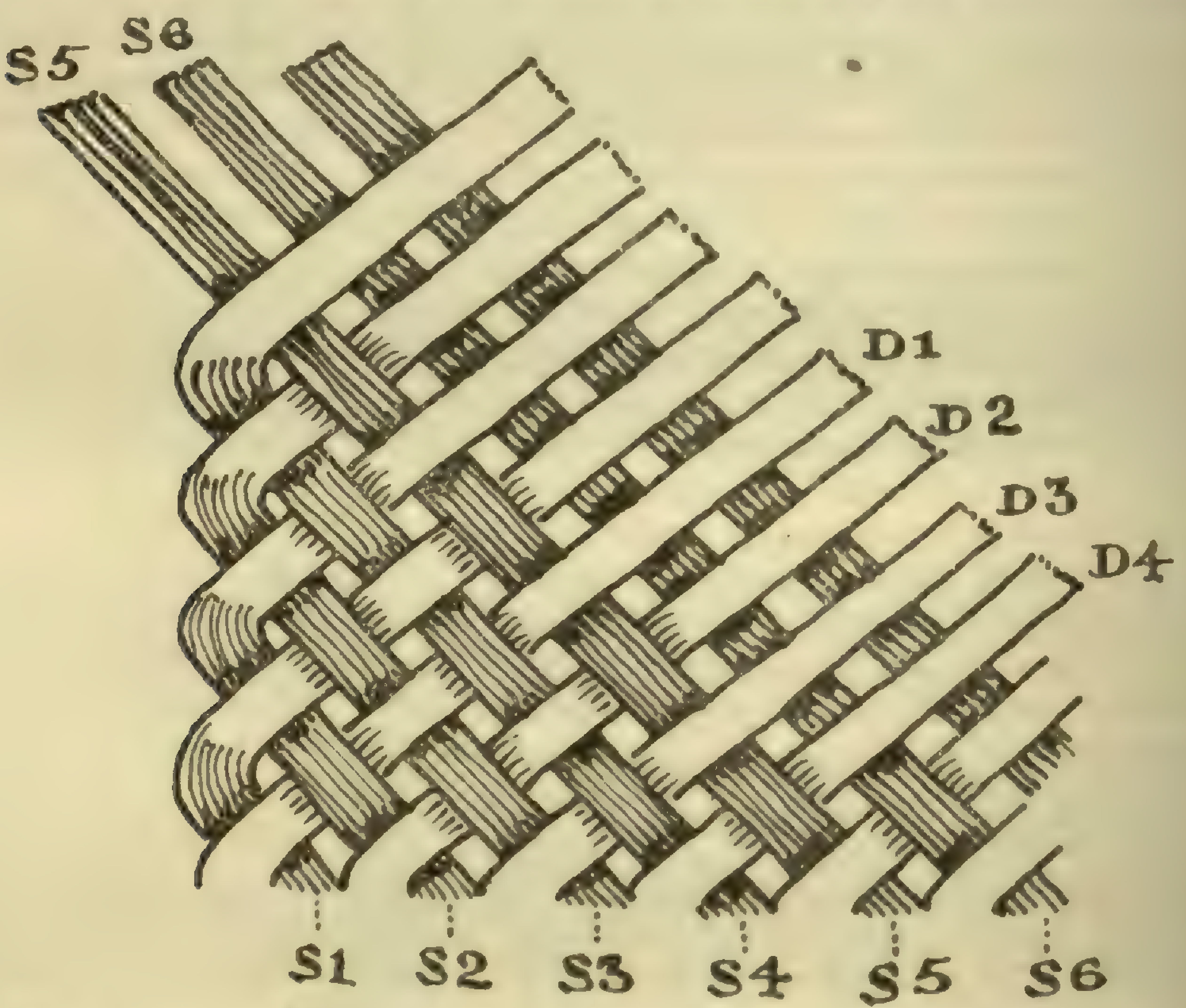


Fig. 1.—Commencement of weaving a *taka* mat, showing arrangement of dextral and sinistral wefts.

Another series is now commenced from the left, and so by successive widths, with an advancing diagonal edge, the body of the article is completed. Whilst plaiting, the dextrals that have just been done with are looped back out of the way, so as not to get their free ends mixed up with the sinistrals. On completion of the strip of plaiting the dextrals are allowed to fall back into their natural position. Thus on commencing a fresh strip of plaiting the dextrals and sinistrals are in two distinct layers, the dextrals being above. The upper layer of dextrals, as we have seen, is first dealt with by the left hand separating a number of wefts, and from the under layer of sinistrals the right hand then picks up one weft and places it in position. Thus the keeping of the two layers distinct renders the work much easier and avoids confusion. Plate 78, fig. 2, shows the lower layer of sinistrals, the dextrals finished with looped over on the left, and those to be dealt with in their normal position on the right. The first completed strip of

plaiting and the advancing diagonal edge of the second strip are shown very clearly. Although the plait figured is a twilled two, except for the actual stroke used it illustrates checker-work equally well.

Checker-work is usually done on the rougher articles, such as small baskets for cooked food, baskets, and sometimes mats, made from the rough wefts.

Twilled work is distinguished as "twilled twos" or "twilled threes," &c., according as each weft passes over or under two or three, &c., crossing wefts. A twilled two is a very favourite plait. This stroke is commonly known as a *rangarua* (two-plait). The Whanganui people have different names according as the lines of the pattern are horizontal (*pae*) or vertical (*tu*). The names *pae* and *tu* simply mean horizontal and vertical, but are only applied to twilled twos. Anything more than a two, such as twilled threes, &c., are called *hora* (spread out). These are usually introduced into the coloured designs, but a row or rows of threes are sometimes worked on floor-mats and the better baskets.

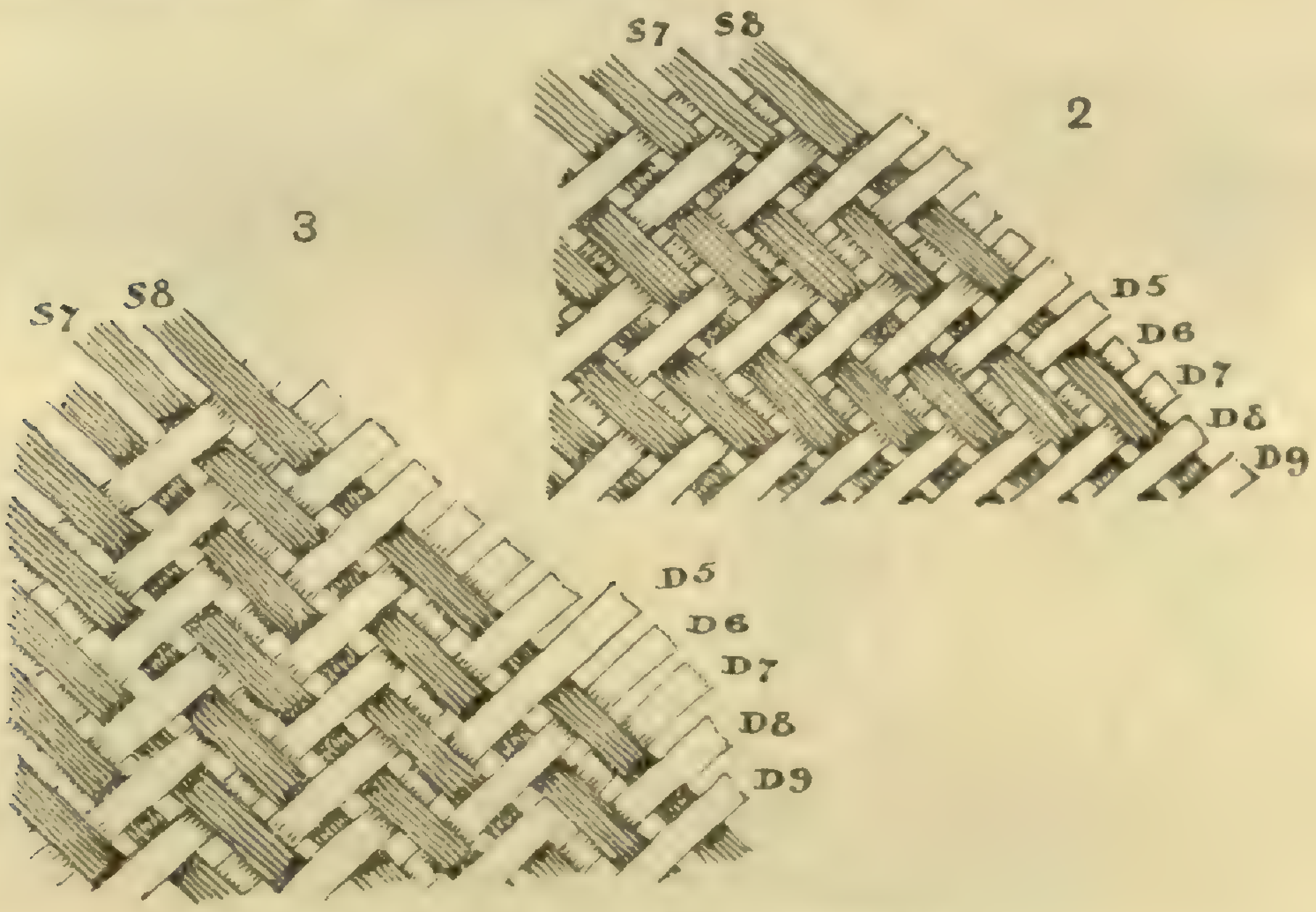


Fig. 2.—Twilled twos, horizontal.
Fig. 3.—Twilled twos, vertical.

The technique of twilled work is similar to that of checker-work, except, of course, that the left hand picks up alternate twos or threes, &c., of dextrals whilst the one sinistral is placed through as above. As the work progresses, the plaiting-in of each sinistral adds another dextral and necessitates a rearrangement of the dextral series. In a horizontal twilled two the upper dextrals of the previous series passing over the sinistrals are dropped and the upper of those passing under are picked up. The lower dextrals in each case are carried on. Referring to fig. 2, mark the course of the sinistral S7. The dextrals D8 and D7 pass over it, and D6 and D5 pass under it. In preparing for the next sinistral, S8, another dextral, D9, has come in from below. D9 and D8 are lifted so as to pass over S8, and this causes D7, which was the upper of the previous pair, to be dropped so as to maintain the twilled two. Thus the previous under-pair, D6 and D5, are added to from below, and the upper D5 must be picked up to prevent a three. This is carried on throughout. The skilled plaiters carry

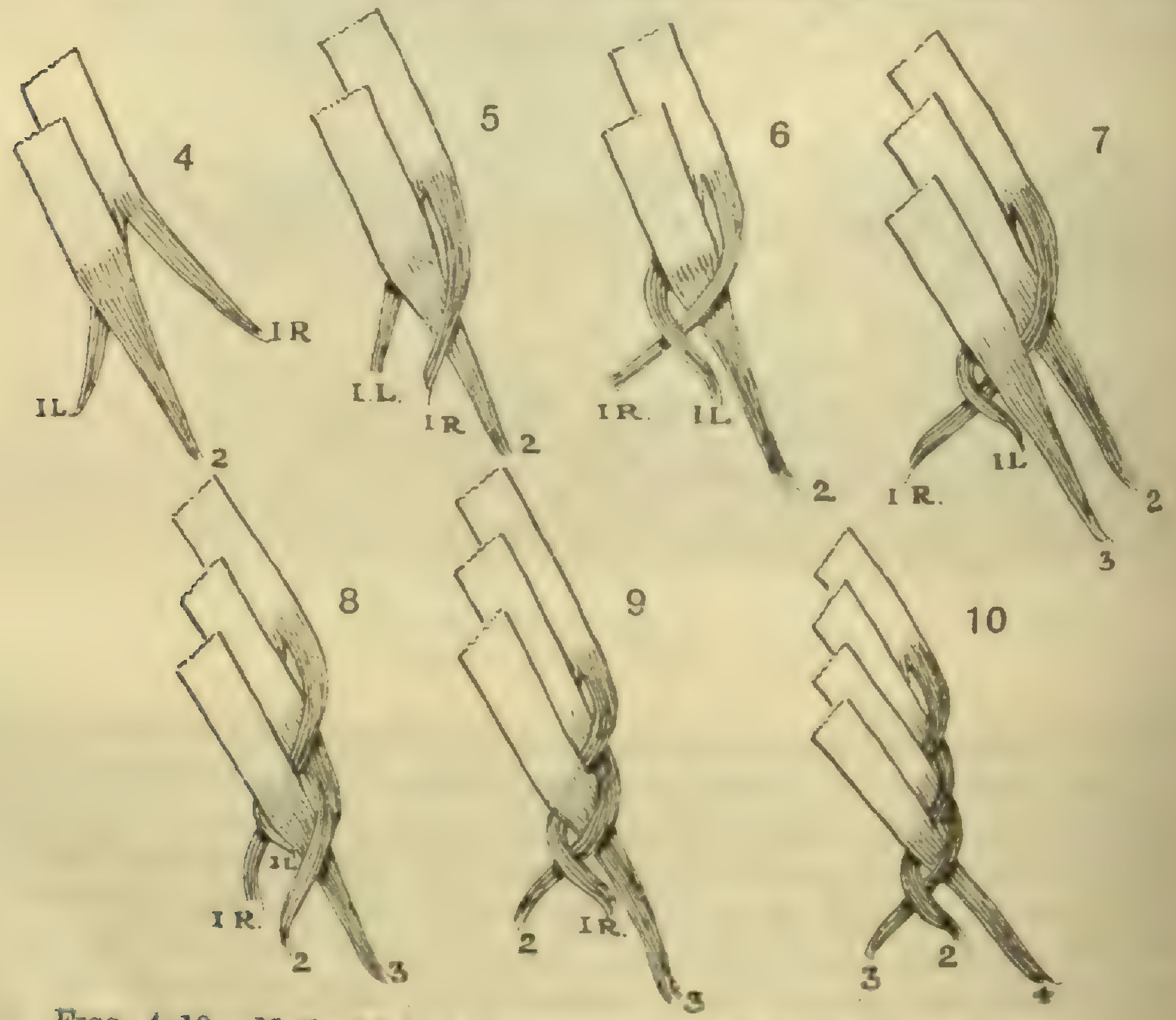
on mechanically, and can pick up and drop the right dextrals by the sense of touch. In the vertical twilled two, instead of the upper dextral of each pair being changed, it is the *lower*. In fig. 3, follow the course of the sinistral S7 : the dextrals D8 and D7 pass under and D6 and D5 pass over it. For the next sinistral, S8, the lower of the previous pair passing under D8 is picked up, and the upper, D7, is carried on. The lower of the pair passing over, D6, is dropped to join D7. D5, the upper of the pair, is kept up, and will be joined by the lower of the next pair being picked up. Thus, in plaiting, the automatic picking up and dropping of the lower or upper of each pair of dextrals works a vertical or horizontal twilled two with absolute exactness.

Both in mats and baskets it is usual to commence with a horizontal twilled two. Later on the stroke may be changed to the vertical. A variety of designs can be obtained by plaiting alternate widths of horizontal and vertical patterns, and even alternating with checker-work.

Articles manufactured.

(1.) *Mats.*

The term "mats" is here confined to plaited articles for sitting or sleeping upon, and coverings used for domestic purposes. The Maori, unlike the Samoan, Hawaiian, and others, did not plait mats for apparel.



Figs. 4–10.—Method (*a*) of commencing the twist, or plait, *whiri.*

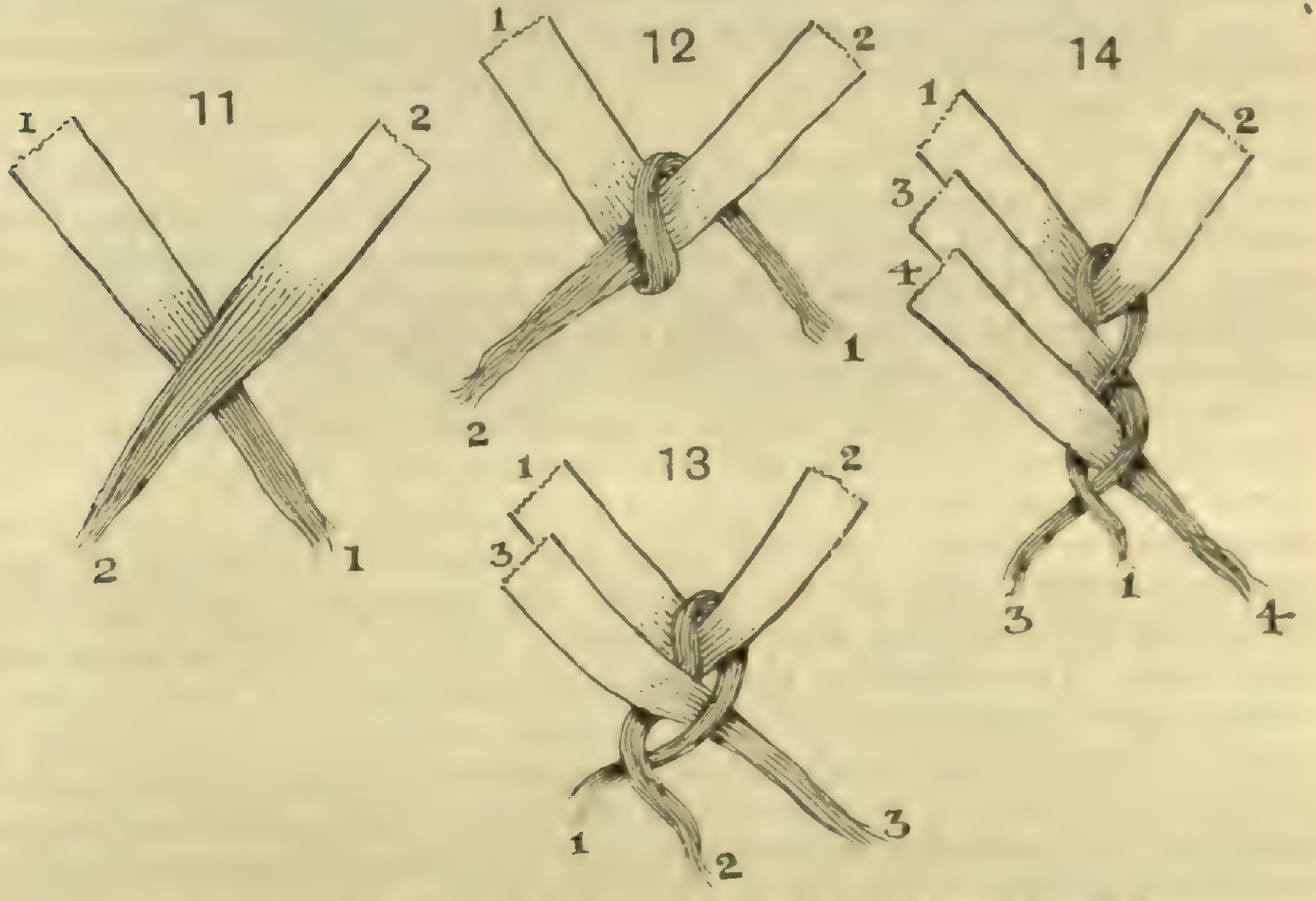
The word "mat" has often been applied to cloaks and capes. This use of the word is to be strongly deprecated, as those articles of clothing were woven from prepared flax-fibre. It would be just as reasonable for a Maori to call a tweed coat a piece of linoleum.

Floor-mats come under the general term *whariki*. *Whariki* means anything spread on the ground or floor; and it includes, nowadays.

anything from leaves or fern to a Persian carpet. Floor-mats consist of two kinds—the rough, quickly made mats for everyday use, and the better-class sleeping-mat, usually with designs plaited in with coloured wefts.

Ordinary Floor-mats (*Taka*).—These mats have a variety of names according to district, such as *pokipoki*, *tamata*, *hipora*, &c. They are made from the natural wefts of the *Phormium tenax*. The length is usually 6 ft. or more, so as to prove sufficiently long for the reclining figure, whilst the width varies from 2 ft. to 4 ft. according to the length of flax-blades from which the wefts have been prepared.

The beginning consists of plaiting the butt-tufts of the wefts together with a three-ply plait until the required length of 6 ft. or so is reached. This stage is called *whiri* ("twist," or "plait"). There are three ways of commencing the *whiri*.



FIGS. 11–14.—Method (*b*) of commencing the twist, or plait, *whiri*.

(*a*.) The first weft has its butt-tuft split and diverged into two equal parts. The second weft is placed parallel with the first, overlapping its left edge and crossing the left half of its divided butt-tuft. Reference to the figures shows that there are now three tufts of fibre which form the basis for the three-ply plait. The right tuft (1R) is twisted over the middle tuft (2), and then the left tuft (1L) is twisted over it to the middle position (fig. 6). A third weft is overlapped along weft 2, as in fig. 7. The plaiting is repeated as before. It will be noted that the butt-tuft of the new weft is in the middle with the end of the previous middle tuft (1L), and they are treated as one element in the three-ply plaiting. The right tuft (2) is twisted over to the middle (fig. 8), and then the left tuft (1R) is twisted over it to take up the middle position (fig. 9). The addition of weft 4 and the right and left twists results in fig. 10. Wefts are added singly in this manner until the required length is reached, when the fibrous tufts are continued on in a three-ply plait and tied in a knot. To get a closer plait in the body of the mat, double wefts are plaited in every here and there along the course of the *whiri*.

(*b*.) In the above method of commencement there is a tendency for the first weft to split up from the division of the butt-tuft. To prevent this the basket beginning is used. The first weft is not divided at its butt-tuft. The second weft is crossed over it (fig. 11). The butt-tuft of weft 1 is twisted over weft 2 and carried down behind it to the right (fig. 12). A third weft is added by overlapping it along weft 1. We have now our three elements for the three-ply plait. To fix the commencement firmly, the right tuft 1 is twisted over tuft 3 to the middle, and then the left tuft twisted over it to occupy the middle position, as in figs. 13 and 14. From now on the procedure of method (*a*) is carried on. Each additional weft overlaps the preceding one on the left, and its butt-tuft merges with the one occupying the middle position. On completion, the second weft, which sticks out from the line of the others, is simply bent into the same line on commencing plaiting the body of the mat.

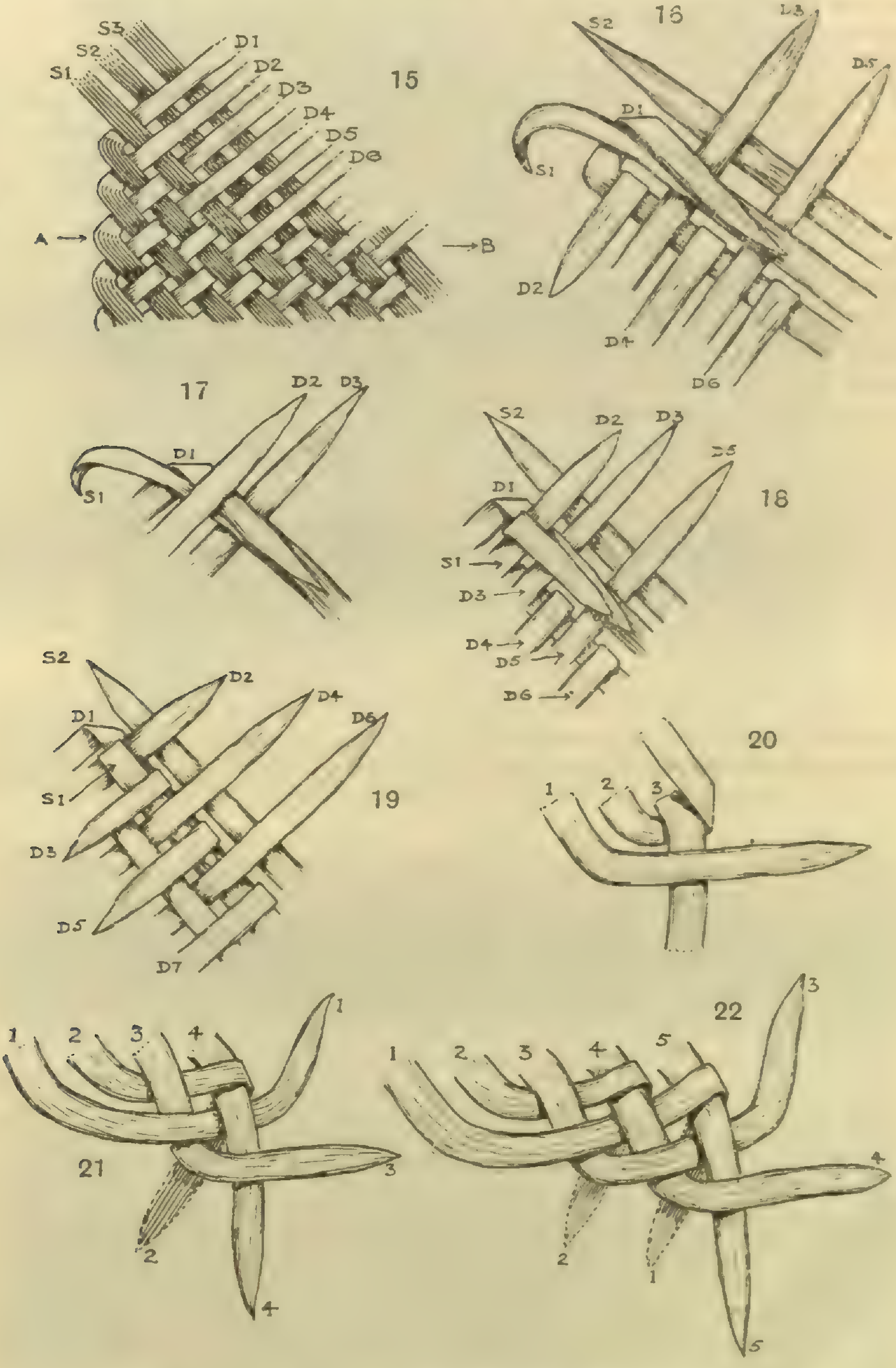
(*c*.) The third commencement is seen in the *tapora* mats for covering food in the cooking-ovens. In this a three-ply cord is commenced with ordinary strips of flax, and then the butt-tufts of the wefts are plaited in on the left side, as in the usual *whiri*. In the case of the *tapora* a cord long enough to form a loop for hanging up is plaited, but in the ordinary floor-mat just enough is plaited to fix the commencement ere including the wefts. During the progress of the *whiri* the butt ends of the wefts are held in position by the left hand, whilst the right hand adds the fresh wefts and twists the butt-tufts into position.

The body of the mat is usually plaited with a twilled-two stroke in horizontal or vertical lines; and combinations of the two are used. The check stroke may be used entirely or in combinations with twilled twos. As pointed out already, the side edges are defined by turning in the projecting sinistral wefts on the left and the dextrals on the right. In turning in the wefts they are merely bent so that the same surface is kept uppermost. The surfaces of the wefts corresponding to the inner or upper surface of the plant-leaf are kept uppermost on the body of the mat, so that the better colour and smoother surface of the completed mat will show when in use. A twisted turn at the edges would expose the different shade of the under-surface and give an ugly mixed appearance to the completed article. When the body of the mat is of the requisite width the plaiter makes sure that the upper edge finishes on the same parallel of strokes from side to side.

The finish in these mats is the process called *tapiki* by most tribes, but *kopetipeti* by the Whanganui. The mat is turned over so that the finish may not be seen on the upper surface. As mentioned in describing the technique of checker-work, the dextral wefts form the upper layer and the sinistrals the lower. On turning the mat, the sinistrals form the upper layer, but they now lean towards the right, whilst the lower layer of dextrals lean towards the left. To avoid confusion it is better to refer to the wefts in their altered position according to the direction in which they lean. Thus the upper layer becomes dextral and the lower sinistral.

The finish is carried out by plaiting a width from the left with the usual diagonal advancing edge of about six dextrals. The edge of the upper border is formed by turning back the dextrals and sinistrals into the body of the mat by twisting and doubling them along the course of the sinistrals, and keeping them in position by plaiting the other dextrals of the series of six over and under them in the usual way. In fig. 15 the line AB denotes the line of completed plaiting for the full length of a mat done with a check

stroke. The left edge has been continued until there are six dextrals above the completed edge. The left projecting sinistral is marked S1. The problem is to turn the left sinistral, S1, and the left dextral, D1, back into the body of the mat along the course of S1 and fix them in position by



FIGS. 15–19.—Method of finishing edge of mat.
FIGS. 20–22.—Method of making the secure *hiki* finish.

the ordinary plaiting of the dextrals. It will be noted that D1 passes *under* S1. The alternative dextrals, D2, D4, and D6, which pass over S1, are lifted with the left hand, and in fig. 16 are turned back to make the

process clear. The upper border is commenced by twisting over the first dextral, D1, at right angles to its own course, and laying it along the course of S1. In this turn the weft is twisted over so as to expose its other surface, whereas in the side borders the wefts are bent into the body without changing its surface. D1 is now fixed down by dropping D2 across it in its normal course (fig. 17).

The turning of the mat-edge is completed, for this series, by doubling back S1 over D2 to lie over the turned-back portion of D1 and along its own course (fig. 18). The remainder of the dextral series are dealt with in the ordinary manner. The under-wefts (D3 and D5) are picked up, and the over-wefts (D4 and D6) pressed down over the course of S1. Thus in the new combination D2, D4, and D6 are down, whilst D3 and D5 are turned back; and to complete the series of six a fresh dextral (D7) is picked up (fig. 19). We perceive that the first dextral and sinistral on the left have been disposed of, and the process of plaiting has opened up a fresh series of alternate dextrals for the next sinistral. S2 is now placed in position between them, and by carrying on as above the next two wefts on the left, D2 and S2, are disposed of. So it is continued to the right edge.

Where the wefts are long and project beyond the lowest crossing dextral the ends are cut off. At the right corner the weft-ends which cannot be doubled back are plaited into a three-ply braid and knotted against the edge.

In the *taka* type of mat the *kopetipeti* finish is usually quite enough. Some of these mats, however, are made much better by having the wefts lightly scraped. To some of them, as well as to the best-class mats, the additional finish called *hiki* is applied.

The *hiki* finish is used after the *kopetipeti* finish to make doubly secure the weft-ends and prevent the edge unravelling. Thus the weft-ends have to be sufficiently long to permit of their being plaited in a three-ply plait. By dropping one weft as a new weft is picked up, the actual elements plaited consist of three throughout.

The plait commences from the left. It will be remembered that in the *kopetipeti* finish the weft-ends are in twos, a dextral and a sinistral being together. These pairs are treated and numbered as single wefts. Take the first three wefts on the end, numbering from the left. Proceed as in ordinary three-ply plaiting. The right weft (3) is brought over the middle one (2) and then the left weft (1) is brought over it to occupy the middle position (fig. 20).

From now on, as each new weft is taken up, the old weft on the right is discarded. This discard is accomplished by turning it back first of all to allow the new weft to be brought down over the middle one, and then as a last movement twisting it over the base of the new weft and pushing it under and to the left, where it is kept by the ring and little fingers of the left hand. Applying these principles in fig. 21, a new weft (4) is drawn over the middle weft (1), and the left weft (3) is drawn over it to occupy the middle position. The old right weft (2) is twisted over the base of the new weft (4) and pushed to the back and the left, where it is discarded. The new series consists of 3 in the middle, 4 on the left, and 1 on the right. The weft on the right (1) is pushed back to allow the new weft (5) to be brought down over the middle weft (3). The left weft (4) is brought over 5 to the middle position, whilst the old right weft (1) is twisted over the base of the new weft (5) and discarded, as seen in fig. 22. By continuing in this manner and exercising enough pressure to tighten the wefts, the *hiki* finish is carried across to the right edge and the upper border rendered secure,

[J. McDonald, photo.

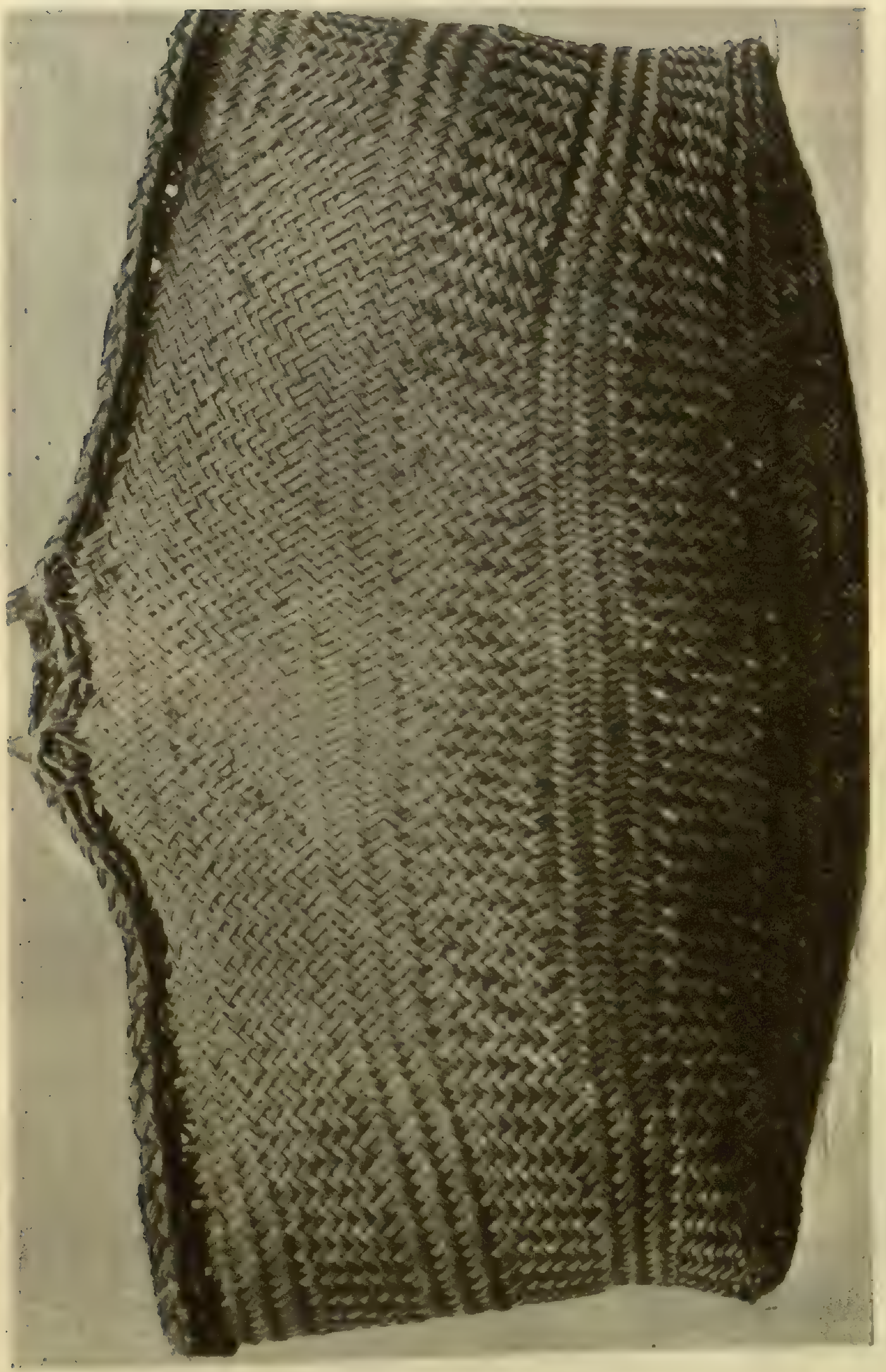
FIG. 1.—A completed *kono*, or food-basket. The young woman, seated on *taka* mat, with *Phormium tenax* at her back.

[J. McDonald, photo.

FIG. 2.—*Taka* mat in twilled twos. Shows two layers of wefts and diagonal working edge—lower layer of sinistrals, dextrals finished with looped over to left, and those to be dealt with in normal position on right. Note position of left foot, which steadies the work.

[J. McDonald, photo.

Laying the keel of *kete*, or satchel-basket.



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A completed *kete*. Shows horizontal and vertical lines of twilled twos and three-ply upper border; also shows greater depth at middle than at ends.

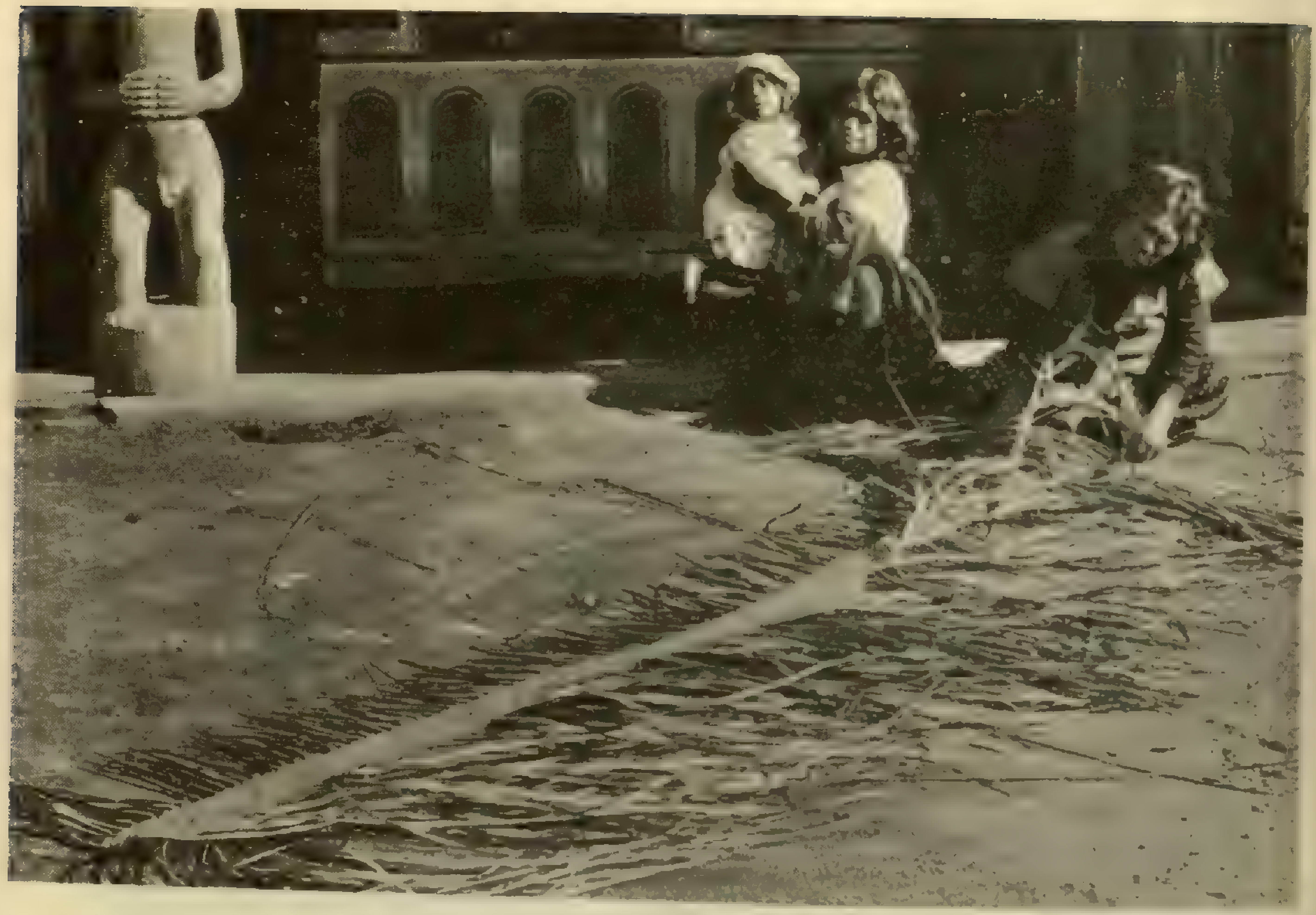

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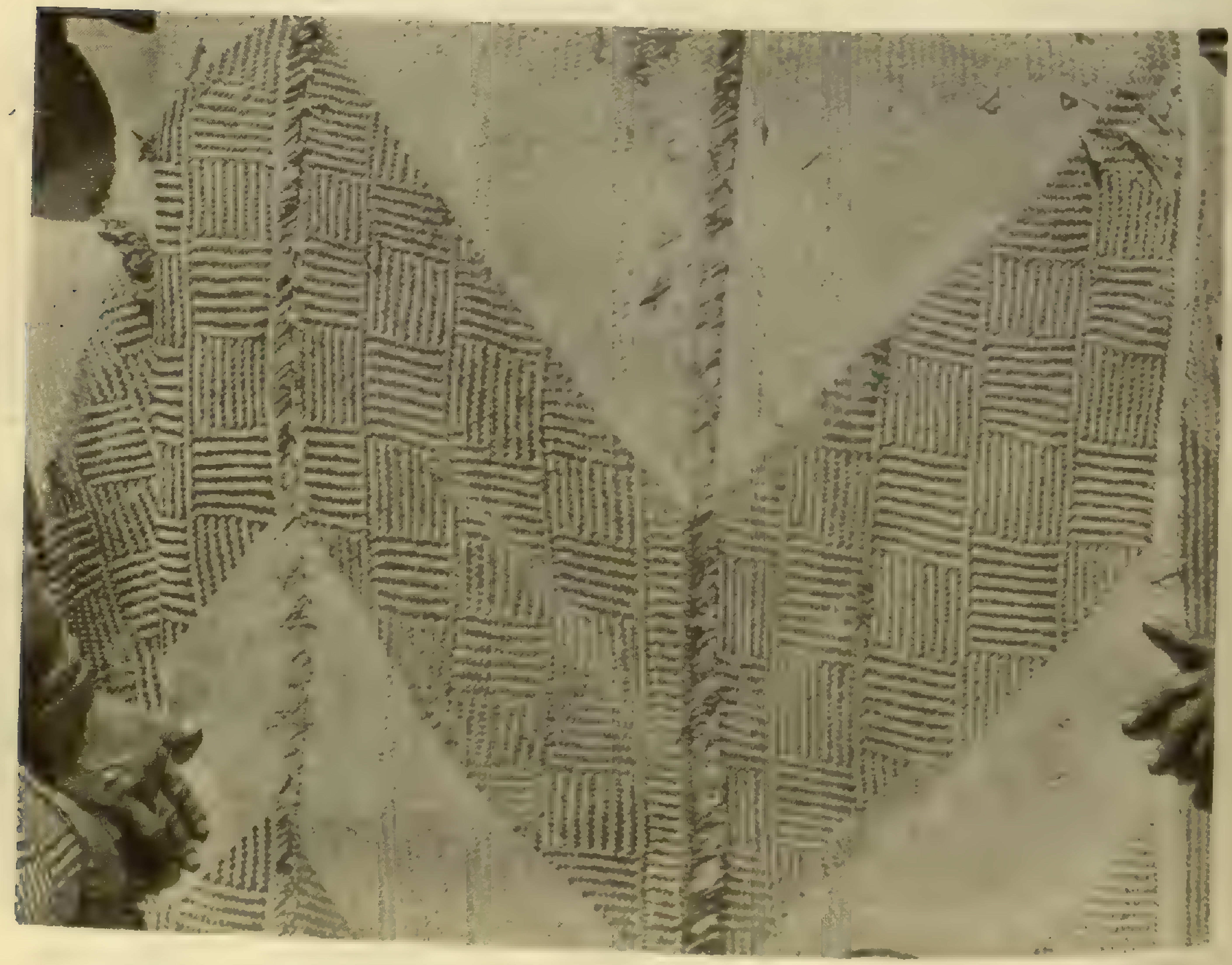
FIG. 1.—*Porera* mat, in check. Shows undivided butt-pieces carrying two wefts.



[J. McDonald, photo.

FIG. 2.—*Porera* mat, showing two *whara* divisions and three joins. It has been folded under on left where held by hand.

the loose projecting ends being finally cut off. Owing to the narrowing of the flax-blade towards the butt-junction, the wefts partake of this narrowing. The part of the mat, therefore, near the three-ply-plait border made from the butt-tufts is more open than the rest of the mat. Though, in plaiting the mat, we have spoken of the "lower" and "upper" borders, when the completed mat is in use it is placed longways and these two borders become the sides.

A variety of mat for very rough use is made with very wide wefts, almost the full width of the half-blade of flax. Others, again, instead of having butt-tufts for plaiting the beginning, have three or four wefts united by a narrow strip of butt, and these undivided portions of butt form the edge. Another variety, owing to the flax-leaves being short, has two rows of wefts plaited on to the butt-tuft three-ply, beginning as in the basket beginning. The wefts on one side are then plaited in the usual way and finished with the *kopetipeti* ending. The wefts on the other side are then dealt with similarly. Thus we have a mat about 4 ft. wide with the three-ply plait of butt-tufts running down the middle.

The *tapora* mat is another variety. This mat is used to cover the food in the *umu* (cooking-oven) before the earth is heaped over it to seal up the steam. The wefts are lightly scraped (*piahu*), not to make them white but in order to remove some of the epidermis and colouring-matter, so as to prevent them imparting a bitter taste to the food. It is curious that this reason is assigned, as fish are often wrapped up in green flax and cooked in the embers without any taste being imparted to it. It may be that the steam of the *umu* draws out the bitterness of green flax more than the dry heat of the embers.

In the commencement of the beginning of the *tapora*, method (*c*) is used. A three-ply braid of sufficient length to make a loop is plaited, and the butt-tufts of the wefts plaited in as in the *taka*. The body is plaited in checker-work or twilled twos. In the finish, instead of the *kopetipeti*, a three-ply plait is used, as in the case of the ordinary basket. On the left a three-ply braid is plaited to form a loop, and then the wefts, both dextral and sinistral, are added in and plaited along the border until the right edge is reached. The extra length of wefts is carried on in a braid to form another loop. The length is shorter than the *taka*. Thus we have a mat like the *taka* but with a different finish, and with a loop at each corner for use as handles in picking the *tapora* off the hot food when cooked, and for hanging up in the cooking-house when not in use.

Finer mats, *Porera*, or *Tienga*.—The finer mats are made of white and dyed wefts of flax or *kiekie*, and *pingao* is used in the coloured designs. *Kiekie* mats are whiter than flax, and, if carefully looked after, last longer. If bent too sharply in rolling or folding, the wefts are apt to crack, and are then liable to wear into holes. These mats are used for sleeping upon, and all meeting-houses have a set as part of their furnishing. These are kept stored away; but when visitors come the floor is strewn with dried rushes or fern, rough mats placed over it, and then an upper covering of fine *porera* makes the reception-house worthy of both guests and hosts. On the East Coast these mats are called *takapau*. *Porera* are usually about 6 ft. 6 in. in length and 4 ft. 6 in. to 10 ft. or more in width. In some cases very wide mats are made for flooring the meeting-houses.

The beginning: Wefts for these mats do not have the butt ends scraped, therefore the *whiri* beginning of rough mats is inapplicable. The wefts, as previously mentioned, are left united at one end by the butt end of the

half-blade of flax being undivided. The wefts of one butt-piece are used as dextrals and the next as sinistrals, so that the beginning-edge consists of butt-pieces crossing each other, the alternate ones being in the same direction. The butt-pieces prevent the edge from coming loose as the plaiting proceeds. In rough mats quickly made this beginning-edge is sometimes used and left in the completed mat, but with the *porera* it is only temporary. Sometimes, where two wefts to a butt-piece are used throughout, the two wefts are diverged in opposite directions. In cases where the wefts are single, a row of them is laid down and two thin strips of flax are twined round the butt ends in a fitch to keep them in position temporarily for the plaiting. The beginning-edge is continued for the full length of the mat—that is, 6 ft. 6 in. (Plate 81, fig. 1.)

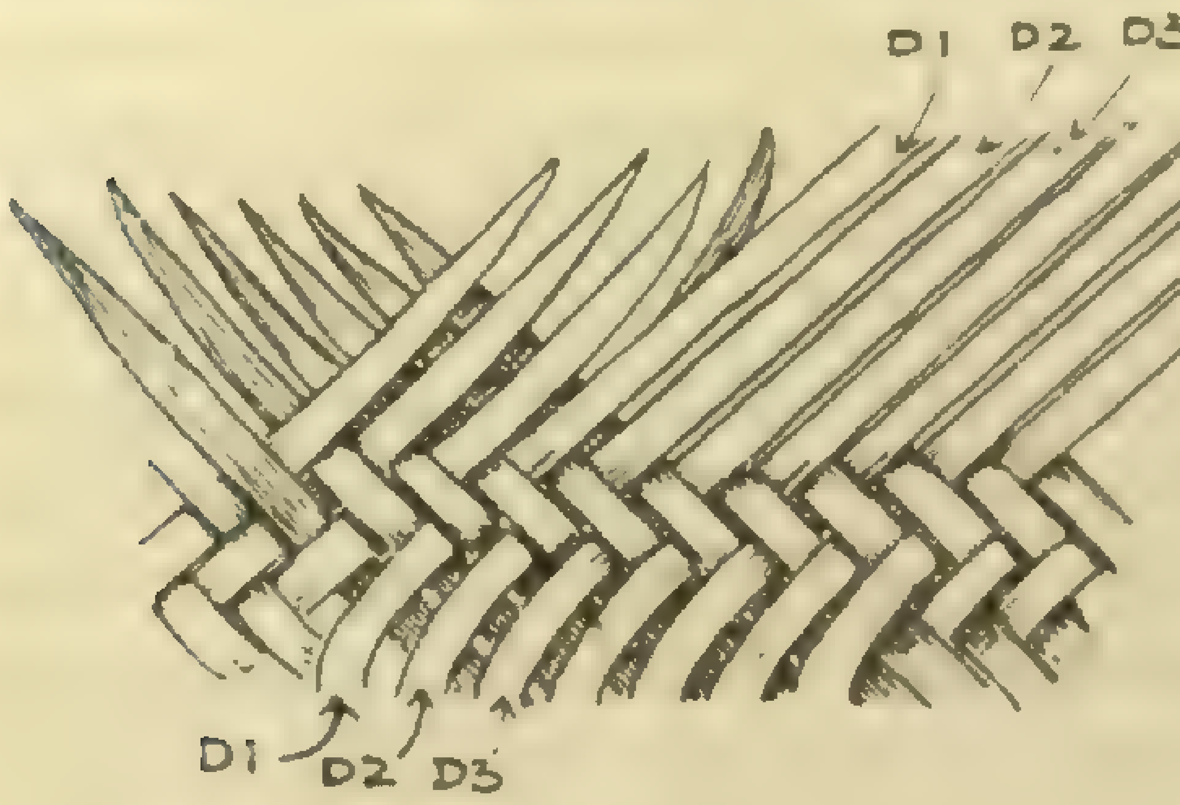
The body is usually plaited in twilled twos, but a check stroke is sometimes used, especially in a fairly common mat made with alternate black and white wefts. Owing to the limited length of the wefts the mat is plaited in narrow widths of from 14 in. to 18 in. (Plate 81, fig. 2.) A width is by some tribes called a *whara*, and by some a *papa*. A *whara* is plaited for the full length of the beginning-edge, and the wefts as they become free at either end are turned back into the body of the plaiting, as in the case of the *taka* mats. This forms edges at right angles to the beginning-edge, and will form sections of the upper and lower borders of the completed mat. Four *whara*, or sections, of 15 in. each make a convenient total width of 5 ft., but this width may be increased by adding more sections. Four *whara* require three joins.

The join is called a *hono* in some districts, and in some a *maurua*. The first *whara* has the weft-ends finished off by turning them back on the under-side in the *kopetipeti* finish described in *taka* mats. Still keeping the section with the under-side uppermost, the undivided butt portions of the beginning-edge are split with the thumb-nail into their component wefts. These free ends can now be joined to a fresh set of wefts necessary to form the next section. Joins are double (*hono rua*) or single (*hono tahi*). The double join is the older one in the Whanganui district, but the single join is more quickly made.

(*a*.) The single join: The first step is to reduplicate the dextral wefts by laying a fresh set along the course of the old set. They are kept in position by pushing the butt ends under two crossing sinistrals at the joining-edge. This is done along the entire edge except for a couple of inches at the left end. The butt ends of the fresh wefts project below the crossing sinistrals for 1 in. or so (fig. 23).

The dextrals are now in pairs, consisting of a newly added long weft and the short end of the old weft. The first movement in adding the fresh sinistrals is to turn back the first two pairs of dextrals on the left. A fresh sinistral is placed along the course of the old sinistral that is exposed. This old sinistral is picked up and drawn tightly along the upper surface of the fresh sinistral, and kept in position with the left thumb (fig. 24). The short weft of the first dextral pair is picked up, drawn taut, and with a quick half-turn bent down at right angles to lie along the course of the fresh sinistral (fig. 25). The long weft of the first dextral pair is then straightened back into its proper position, crossing over the pair of sinistrals (fig. 26). The short sinistral is turned back on its own course over the crossing long dextral (fig. 27). The second pair of dextrals is brought forward to straighten up matters, and then brought back again with a third pair of dextrals. This brings us to the position at the

commencement where there were two pairs of dextrals turned back. A fresh sinistral is added along the course of the next old sinistral, and



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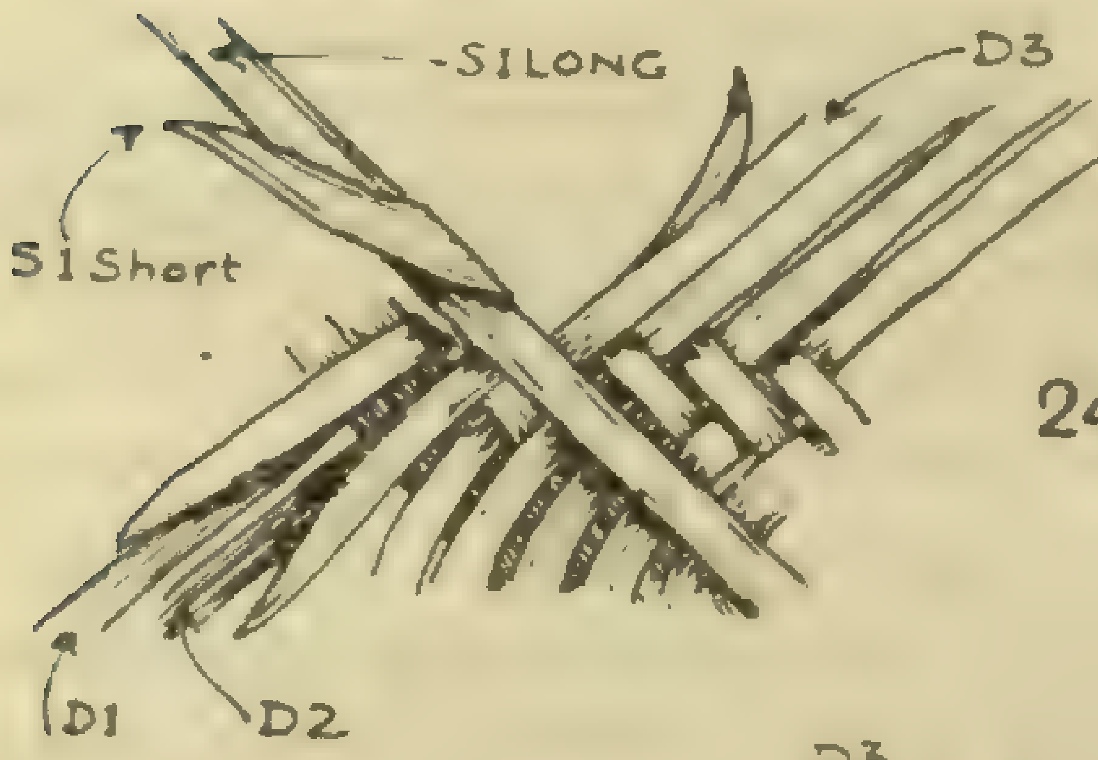

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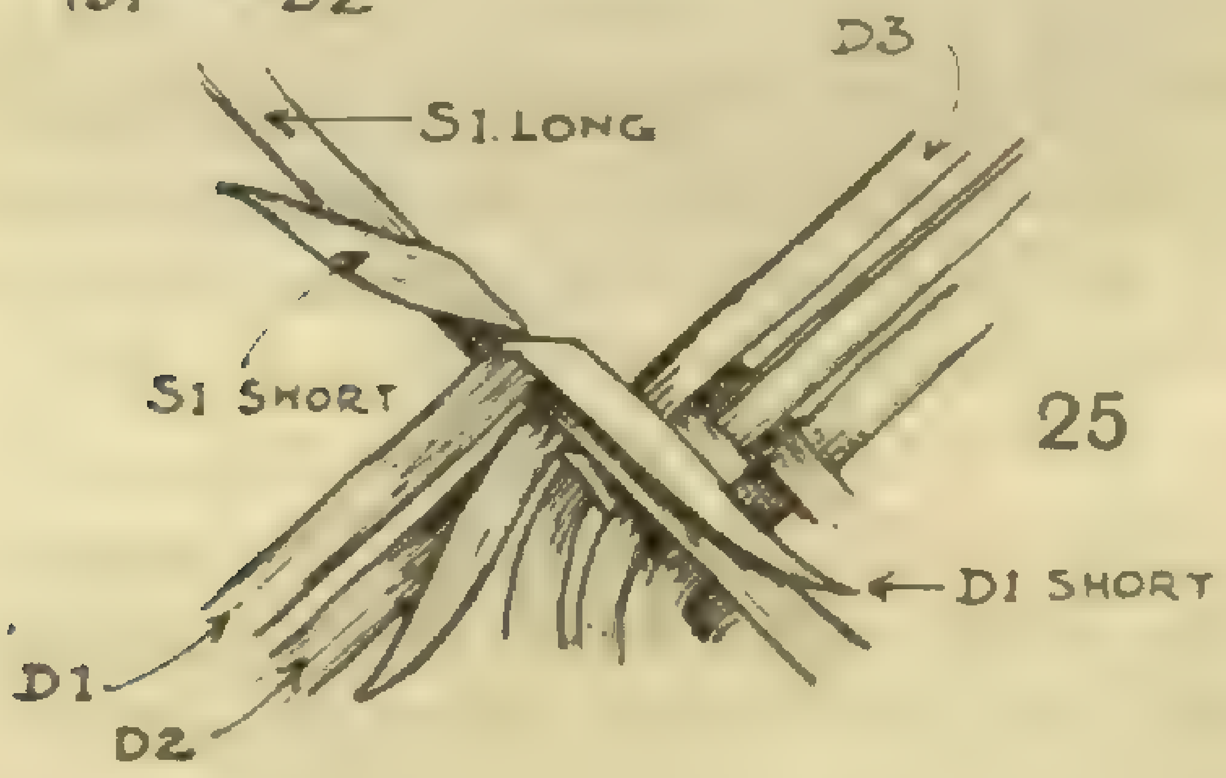

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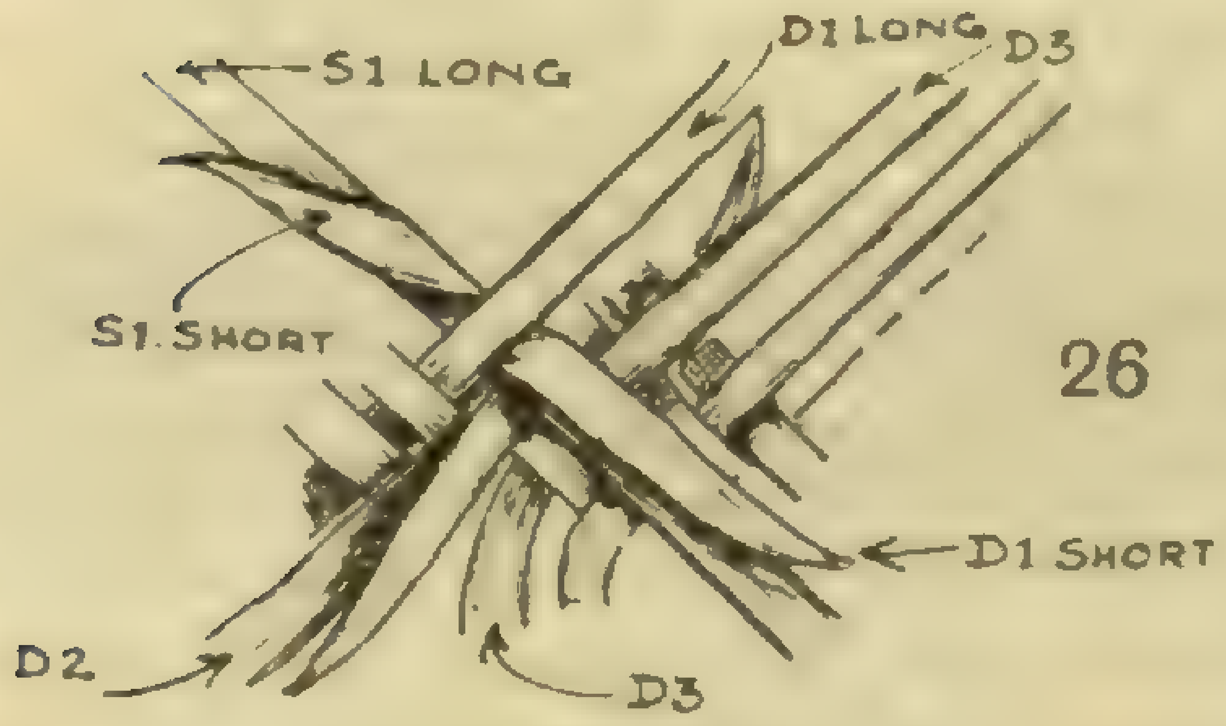

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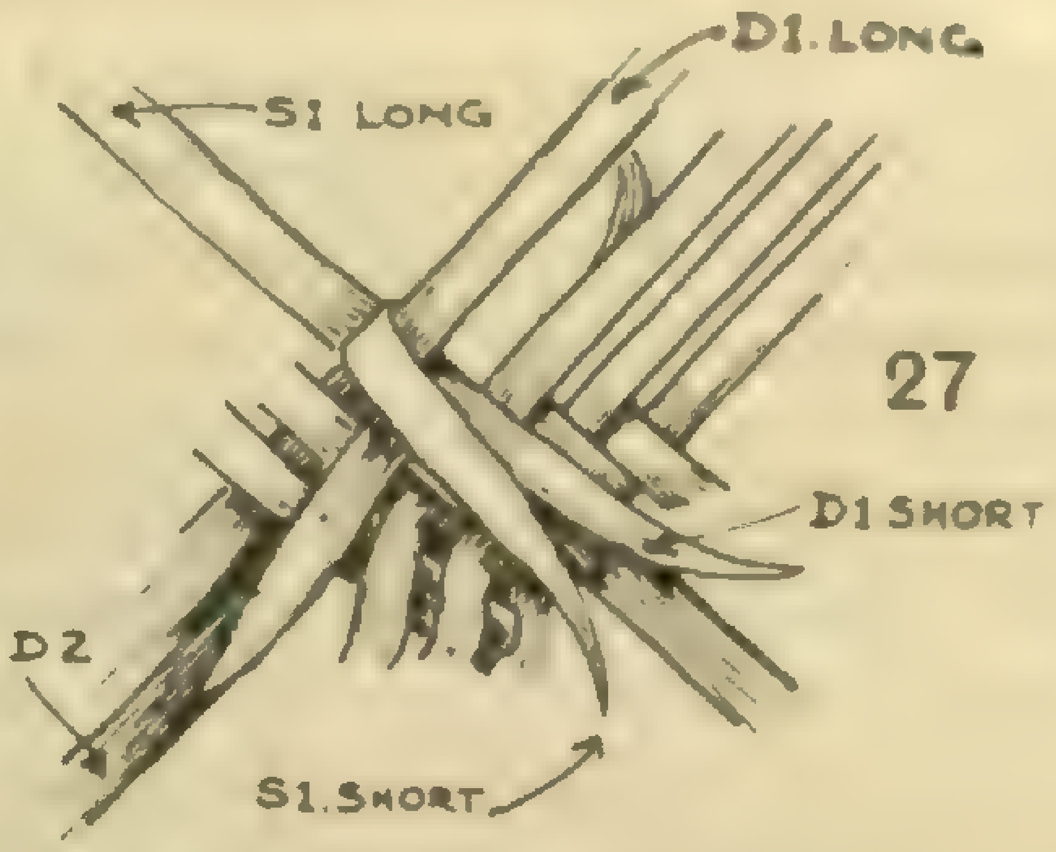

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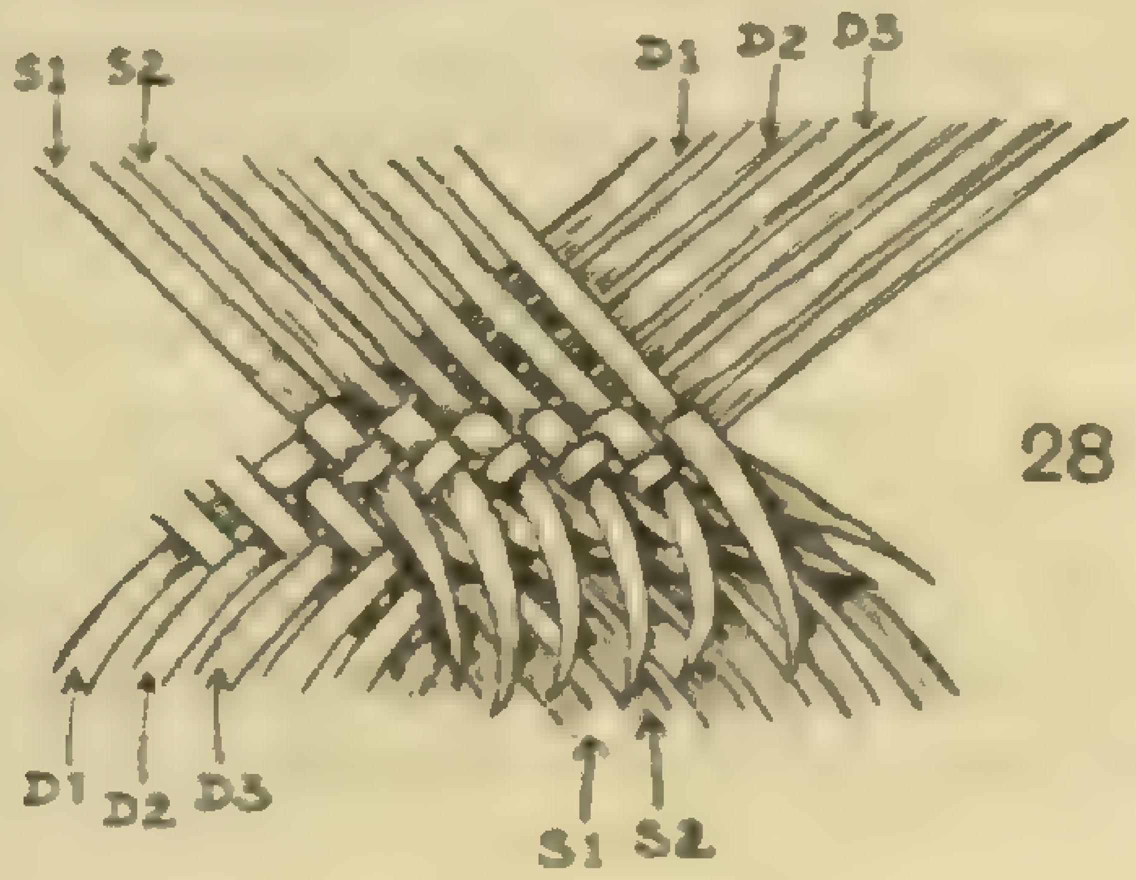

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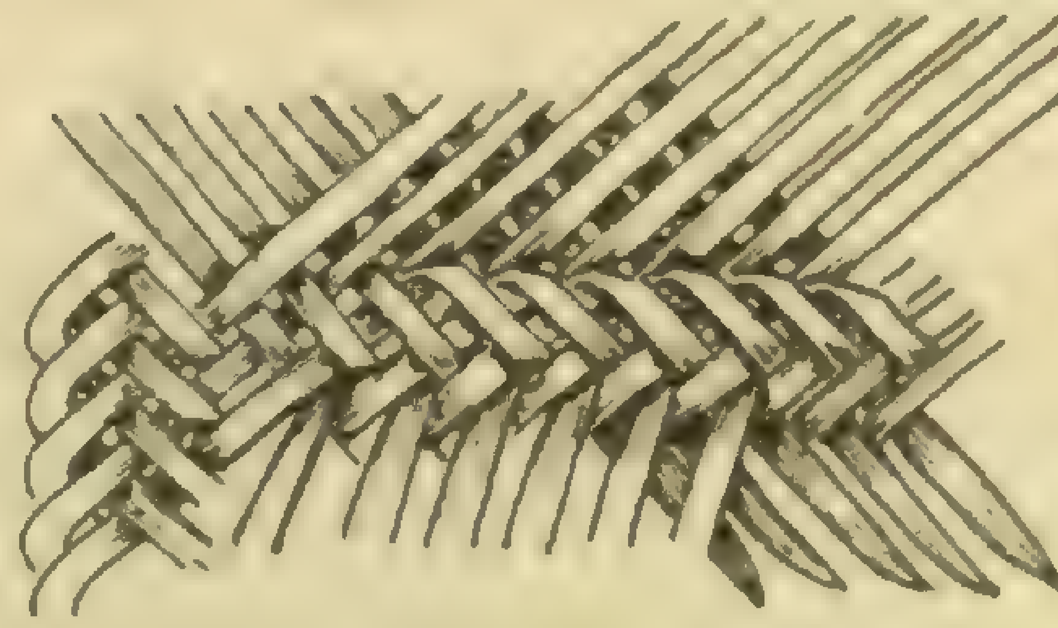

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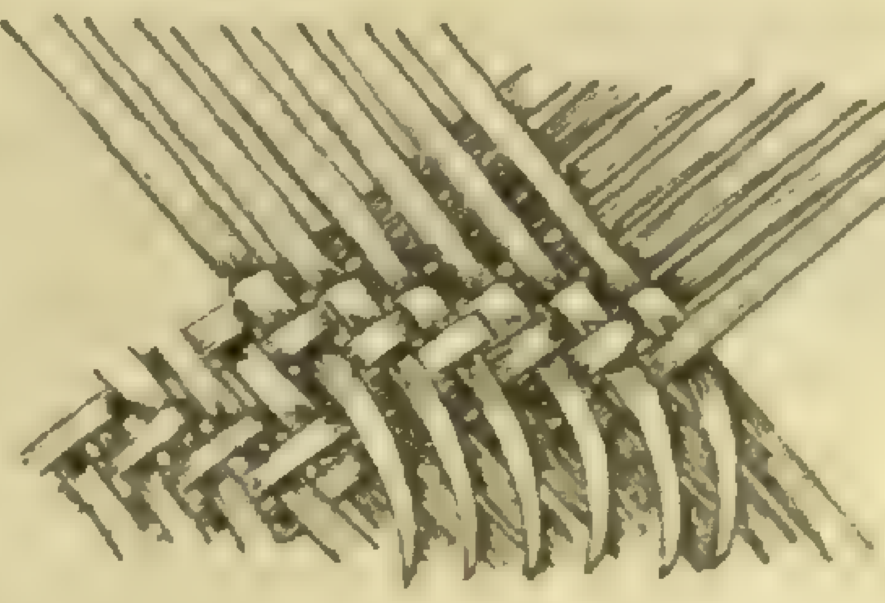

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FIG. 23.—*Porera*, single join. Butt ends of fresh dextrals pushed under two crossing sinistrals, showing space on left where old dextrals are not reduplicated.

FIGS. 24–27.—*Porera*, single join. Steps in adding fresh sinistral.

FIG. 28.—*Porera*, single join. Section of completed join, showing fresh dextrals and sinistrals in position, and resulting fringe with under layer of dextral butt ends directed to left and upper triple layer of sinistral butt ends, and tips of old dextrals and sinistrals directed slanting to the right.

FIG. 29.—*Porera*, double join. First stage, showing addition of fresh set of dextrals, with resulting fringe composed of butt ends of fresh dextrals slanting to the left, and under layer of tip ends of old dextrals slanting to the right.

FIG. 30.—*Porera*, double join. Second stage, showing addition of fresh set of sinistrals, with resulting fringe of butt ends of fresh sinistrals below and tip ends of old sinistrals above, both slanting to the right.

the above process repeated. When the second long dextral is in position it effectually fixes down the ends of the first short dextral and the first short sinistral (fig. 28). This is continued throughout.

It is readily seen that the fresh dextrals were added by pushing the butt ends under two crossing sinistrals already plaited into position. The fresh sinistrals by the second part of the joining process are crossed by two dextrals, and thus the twilled-two stroke is maintained throughout the join. The continuation of the twilled-two plaiting keeps them all firmly in position. The short ends of the old dextrals and sinistrals are disposed of by turning them back and to the right. In the resulting fringe of weft-ends we have a layer of the butt ends of the fresh dextrals slanting towards the left, and above that a triple layer of the butt ends of the fresh sinistrals and the tip ends of the old dextrals and sinistrals slanting to the right. These ends are trimmed off evenly, but remain as a fringe on the under-surface of the mat. On the left end of the join the ordinary twilled plaiting is continued, and the side edge continued by bending back the sinistral wefts into the body. On plaiting forward for 2 in. or 3 in. it will be found that a number of dextral wefts on the extreme left that have not been replaced by fresh ones, together with unreplaced sinistrals that have been turned in from the left side edge to function as dextrals, are becoming short. These are now replaced with fresh dextrals, making a short join parallel with the main join and about 3 in. in front of it. It is called a *pahupahu*. At the right end of the join a similar *pahupahu* join is made for the sinistrals.

(*b.*) The double join: In the double join the dextrals are joined first in a separate row. The fresh dextrals are not pushed under the sinistrals, as in the single join, but are plaited in individually, whilst the short ends of the old dextrals are bent down and to the right, as in the single join, when they are cut off evenly (fig. 29). The first fringe will thus consist of an upper layer of the butt ends of the fresh dextrals slanting down to the left, and an under layer of the tip ends of the old dextrals slanting down to the right. The fresh dextrals and old sinistrals are plaited on for 1 in. to 1½ in., and the fresh sinistrals added in an exactly similar manner to the single join, except, of course, that there are no short dextrals to turn back. The short sinistrals are turned back and disposed of as before. In the resulting second fringe (fig. 30) the two layers of ends are both directed down towards the right, the upper being the tip ends of the old sinistrals and the other the butt ends of the fresh.

In the double join there are two rows of fringes, as against one in the single. Some tribes call the fringe a *hiki*, and thus call the double join a *hono* with two *hiki*. As before stated, the Whanganui people restrict the term *hiki* to the three-ply plait done to the weft-ends composing the fringe in order further to secure them.

(*c.*) Another method of joining was used by men in the North Island west-coast district. The weft-ends were plaited with a four-ply plait (*whiri tuamaka*); but this, owing to the ridge formed along the join, was not so comfortable to lie on in the pre-mattress period.

After the join was completed the mat was turned over and the plaiting continued with the proper surface uppermost.

The finish: The outer edge of the first section was finished off in the *kopetipeti* method, and all that remained when the last section had been joined and completed was to finish off its outer edge in a similar fashion. The tribes of the east coast of the North Island call this finish at the edge *tapiki*, and the Taranaki tribes call it *kapeu*.

Many *porera* are made with white wefts alone, and designs may be worked by changing from horizontal to vertical lines of twilled twos. To get neat

work a row of check strokes is used when changing. If the change is made direct there will be a row of alternate twos and threes at the junction. With black and white wefts and yellow *pingao* a great variety of designs were worked. Polynesian mats have the coloured designs done by overlaid plaiting. The coloured wefts are laid on the wefts proper of the mat and plaited with them. They are purely decorative. In Maori mats the coloured wefts enter into the construction of the mat, and thus must go diagonally across the entire width of the *whara*, or section. Broad coloured bands are worked in parallel lines across each section. A series of similar parallel lines may be worked on each section; or, by changing the coloured wefts from sinistrals in one section to dextrals in the next, and fitting the ends together at the joins, a series of broad zigzag bands may be continued across the entire width of the mat. Within the bands themselves a great variety of patterns are introduced. The subject of coloured designs, from its length, must be deferred for special treatment.

At the present day the tribes most skilled in plaiting coloured designs on floor-mats are the Ngati-Kahungunu, of Hawke's Bay; the Ngati-Porou, of the East Coast; and the tribes of the Bay of Plenty district.

Mats of the *porera* type are made from *paopao* or *kutakuta* in exactly the same way. Though they do not last so long, they are much warmer than flax or *kiekie*. It is quite a common habit to show the better *kiekie* mats on the surface in the daytime, and then to reverse the position with the warmer and softer *paopao* mats from beneath when the rugs and blankets are spread for sleep. I saw a *paopao* mat in the North Auckland district with an overlaid coloured design, but it was a recent innovation copied from the Pacific. It is interesting to find that the same material, *Scirpus lacustris*, is widely used for mat-making by the Indians of the Pacific coast of America.

(2.) *Baskets.*

Baskets may be divided into the circular, rimmed type, in which cooked food is served, and the satchel type. The satchels vary in size and material, and are known as *kete* to the Maori and "kits" to the European. *Kete* were used not only as receptacles for containing and carrying material things in, but figure in incantations and mystic rites to enclose the miraculous. The god Tane, as the personified form of knowledge, successfully ascended to the twelfth heaven to obtain from Io the three baskets of occult knowledge. Again, Tane, after Hine-titama the Dawn-maiden had fled from him, collected the stars into four named baskets ere adorning the person of the Sky-father with them. It is interesting to note, from an incantation handed down about one of those astronomical kits, named *whiriwhiri*, that the process of manufacture must have been the same in those god-like days as now. The incantation recorded by S. Percy Smith runs:—

Ka whiriwhiri taku kete
Ka rangaranga taku kete
Ko Tu-tawake taku kete tu.

The ends of the wefts of my basket are being twisted,
The wefts of my basket are being plaited;
My basket is Tu-tawake.

Whiriwhiri, as we shall see, is the process of twisting the scraped ends of the wefts into a three-ply plait which is the special beginning of the Maori *kete*. Before dealing with the two main types of basket, mention must be made of a rare variety of *kete* which forms a link with the ancient home in the islands.

Kete nikau.—This basket was made from the leaf of the *nikau*-palm, and is the direct representative of the rough baskets made in Polynesia from the leaf of the coconut-palm. The women at Koriniti knew such baskets were made in the past, but had forgotten how. One in the Dominion Museum, Wellington, and figured in Hamilton's *Maori Art*, shows that the technique was exactly the same as the rougher island ones. The midrib of the leaf was split down for the desired length of basket, and the two halves, each with its attached row of leaflets, formed the two sides. The midrib portion formed the upper border, whilst the leaflets were treated as wefts already in position and plaited downwards in a check stroke for the requisite depth. They were then finished off on the inside in a three-ply plait along the bottom.

These baskets were made on emergency occasions in the forest, and were not nearly so common as their island prototype.

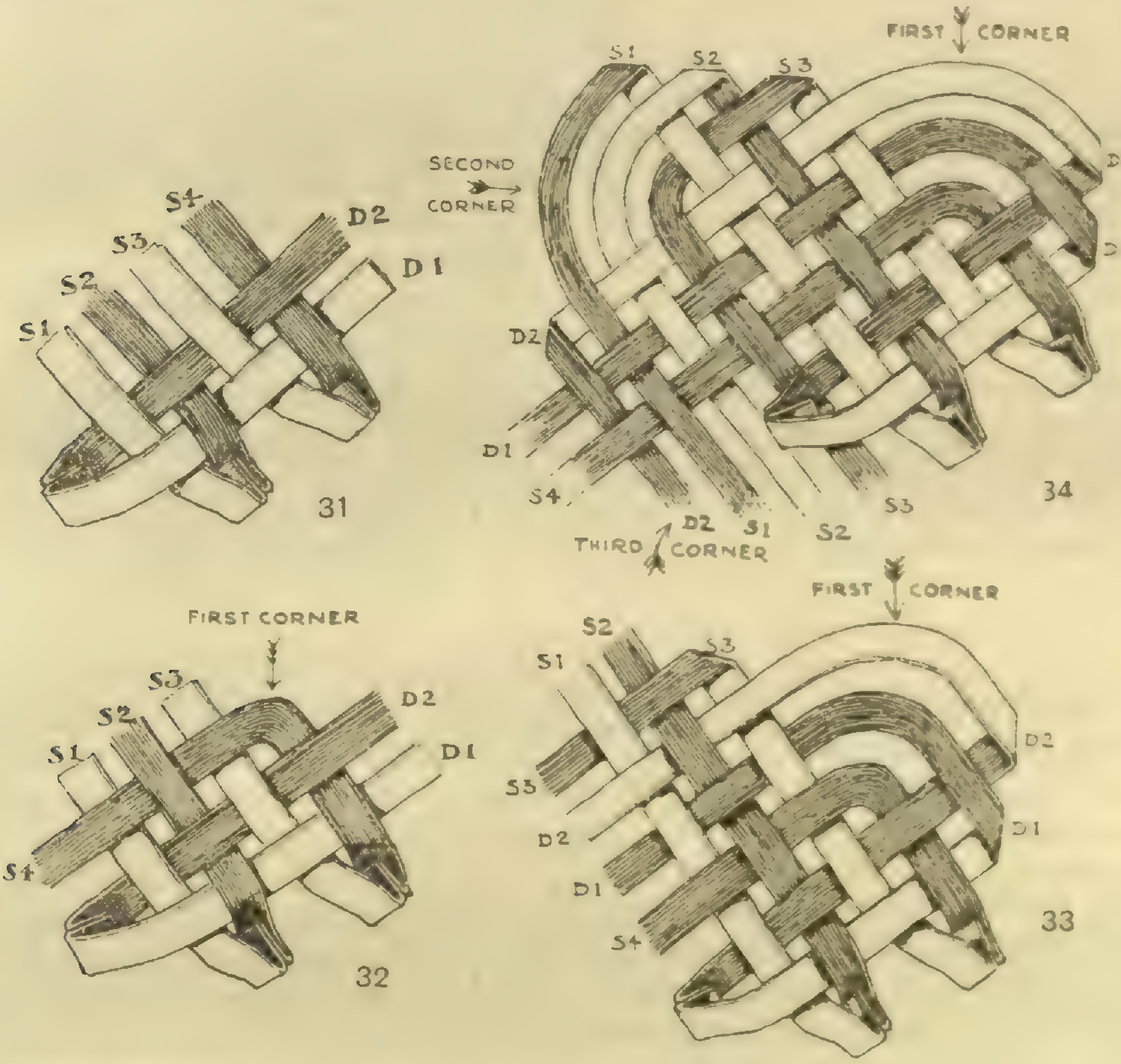
Baskets for Cooked Food.—The *kono* is in shape like a wide-bottomed bowl; but though the rim is circular, from the pliability of the material, the bottom has four corners. It is about 10 in. in diameter and 3 in. deep, but the measurements vary with the width of the flax-blades used.

It is usually made from three full blades of flax, which, after having the margins of the leaf and midrib removed, are split down and left connected by a portion of butt of 1½ in. to 2 in. below the butt-junction. Each weft, consisting of a half-blade, is thus the widest weft obtainable. In splitting down it is difficult to prevent the blades becoming completely separated, and if by care the process is stopped at the right place, below the butt-junction, the pressure brought on the wefts, when plaiting, causes the butt connection to separate. This is prevented by bending the butt backwards and forwards so as to make a crease across it below the butt-junction. This is done first, and as the two half-blades are pulled apart the splitting process stops naturally at the crease, leaving the connecting piece of butt beyond intact. The butt connection is further strengthened by completely bending back the half-blades at the crease, so that the blades are inside out. as it were, and the butt portion is tucked away between the half-blades. This not only strengthens the butt connections but, by concealing them, makes neater work.

The beginning consists in plaiting with a check stroke one pair of wefts through two pairs at right angles (fig. 31). They are drawn tightly together so that the closed ends are locked and nearest to the plaiter. The purpose of the butt connections is easily seen: they prevent the wefts at the beginning from coming apart, and make for neatness and celerity of work. Try to commence a *kono* with six separate wefts and you will appreciate the difference. Maori women, when separation of the pairs sometimes takes place with very stiff flax, quickly tie the butt together again with a thin strip of flax ere attempting to go further.

Fig. 31 shows four sinistral wefts and two dextrals. The right sinistral (S4) is bent at right angles to its course and plaited through the other three sinistrals by raising S2, and depressing S3 and S1 with the left hand. By pulling S4 taut the sinistral and dextral wefts are bent upwards and approximated, whilst the surface of S4, which looked upwards, now looks inward towards the butts. The closing-in of the angle between S4 and D2 forms the first bottom corner, and the alteration in the direction of the surface of S4 begins the side of the *kono* (fig. 32). Through the tightening up of S4 the two dextrals and remaining three sinistrals have been drawn closely together. The right weft of this series of five (D1) is

given a half-twist forwards so as to expose its other surface, and is then plaited through the remaining four wefts of the series so as to continue the check pattern. To do this S3 and S1 are drawn forward and D2 S2 pressed back with the left hand, whilst the right places D1 between them, pulls it taut, and presses it down in close contact with the preceding weft, S4. The next weft on the right (D2) is now given a half-turn, usually forward, and interlaced through the remaining three wefts by raising S2 and pressing back S3 and S1. The next weft on the right (S3), with a half-turn forwards, passes between the remaining two wefts by pressing back S2 and bringing S1 forward. It will be noted that we commenced with a series of four



The making of a *kono*, or basket for cooked food: Fig. 31. the commencement; fig. 32, the first bottom corner; fig. 33, the second bottom corner; fig. 34. the third bottom corner.

sinistrals and two dextrals, and have arrived at a second series of a four on the left and a pair on the right. In the first series it was the right-hand weft of the four that made the corner. It was not twisted, but simply bent. The other three were given a half-twist ere being plaited. The twists form the upper edge of the *kono*, and a forward twist makes it lie more smoothly. However, a back twist may be used; but whichever twist is given must be adhered to throughout. The plaiter, from observing the crossing of the wefts, separates the appropriate wefts with easy accuracy, and the work goes on automatically. The work is also rotated so as to keep the plaiting in front.

Fig. 33 shows the new series of a four on the left and a pair on the right, but to avoid confusion the old numbering is adhered to. The angle between

the four and the pair, on being closed in, will form the second bottom corner. The procedure is exactly as before. The right-hand weft of the four (S3) is bent through the remaining three at right angles to its course, and passes under the projecting end of one of the butt connections. On being drawn taut, the remaining three wefts (D2, D1, and S4) and the pair (S2 and S1) are drawn close together into a series of five and their course directed upwards. S3 has its upper surface turned inwards to continue the side of the *kono*, and its bend forms a second bottom corner. The five wefts are dealt with as before, commencing on the right with half-twists forward, and plaiting throught the wefts on the left till S2, S1, and D2 have joined S3 on the left, and a pair (D1 and S4) remain on the right as in fig. 34. The third series of four and two are dealt with again to form the third bottom corner and the corresponding parts of the bottom, sides, and twisted upper border. When the fourth series of four and two has been dealt with, the plaited work will have come right round under the projecting butt connections and behind the starting-point, and we have a bowl-like basket with four corners at the bottom.

The finish is made by passing one of the wefts of the last pair through an interval below the nearest part of the twisted upper border or rim, bringing it over the rim and tying it to the other weft of the pair with a reef-knot. The ends are cut off, and also those of the four, and the *kono* is complete. (Plate 78, fig. 1.)

The keynote of the work is *he wha, he rua* (a four and two). When the right-hand weft of the four is bent round it is called *whakapoti* (to make a corner). The technique here differs from the usual in that the plaiting works round towards the left.

A larger *kono* is made by using four full blades instead of three. Two full blades are plaited through the other two at right angles, making four dextral wefts and four sinistral. The right-hand blade of the sinistrals, fourth from the left, is used, as in the former *kono*, for forming the corner. Commencing then on the right of the approximated seven wefts, each weft is twisted in turn and plaited to the left through the remainder until one is left. We then get the series of seven wefts to the left and one to the right. The next corner is made by taking the fourth weft of the series of seven, counting from the left, and bending it through the three wefts on its left. Commencing again on the right, the wefts are plaited as before until another series of seven and one is arrived at. This is repeated until the four corners are made and the basket is completed. It is finished off by tying and cutting off the ends as before.

By using the fourth weft for turning the corners the *kono* is the same width at the bottom as the previous one, but the extra material goes into the sides and makes it deeper. If the fifth weft of the left-hand series is used for turning the corners the *kono* will be wider and shallower.

The *kono* is for temporary use, and as the butt portion rests upon the bottom and side of the plaitwork the weak portion of the work is secure enough for ordinary purposes. By continuing the plaiting for another corner the overlap on the outside is increased, and the *kono* rendered more secure. By continuing the plaiting still more a double basket results.

Until comparatively recent times the *kono* was in universal use. At Maori gatherings I have seen women seated by a heap of flax-blades, turning then out rapidly by the score. When the cooking-ovens were opened the *kono* were filled with potatoes or kumara, and a share of meat or fish placed on top. They were then carried by women and men singing

appropriate songs with action-dances, and placed before the visitors, one *kono* sufficing for a couple of guests. The empty *kono* were gathered and thrown away, fresh ones being so easily and quickly made. European plates and dishes have almost completely ousted them, and they are now rarely seen.

A better class of *kono* is made with narrower wefts. The turning of the corners, the plaiting, and the upper border are the same as above. At the finish, however, the ends of the wefts are plaited in three-ply along the free edge from below upwards, and the ends continued into a tail which is passed through a weft-interval near the upper border and simply knotted on the inside of the *kono*, or tied.

The *kono* has a variety of names, such as *paro*, *konae*, *rourou*, &c. Under the name of *rourou* it figures in proverbs as the smallest measure of food. *Te rourou iti Haere* (the little food-basket of the Traveller) is a common expression, and is found in the proverb—

He aha koe i haere mai ai i te rourou iti a Haere?
Te noho atu ai koe i te tokanga nui a Noho?

Why did you come with the little basket of the Traveller?
Why did you not remain with the large basket of Stay-at-home?

This was said by Parewhete in greeting her deserted husband, Wairangi, who had followed her into the midst of numerous enemies with only a small war-party. His life would have been safe had he remained at home in the midst of his powerful tribe, who were the full basket. Instead he had followed with a small handful of men, who were likened to the meagre contents of a *rourou*. Pakaru-a-te-Rangi, of the Ngati-Kahungunu Tribe, in urging unity and combined effort in peace or war, said:—

Nau ko te rourou, naku ko te rourou, ka ora te manuhiri;
Nau ko te rakau, naku ko te rakau, ka whati te hoariri.

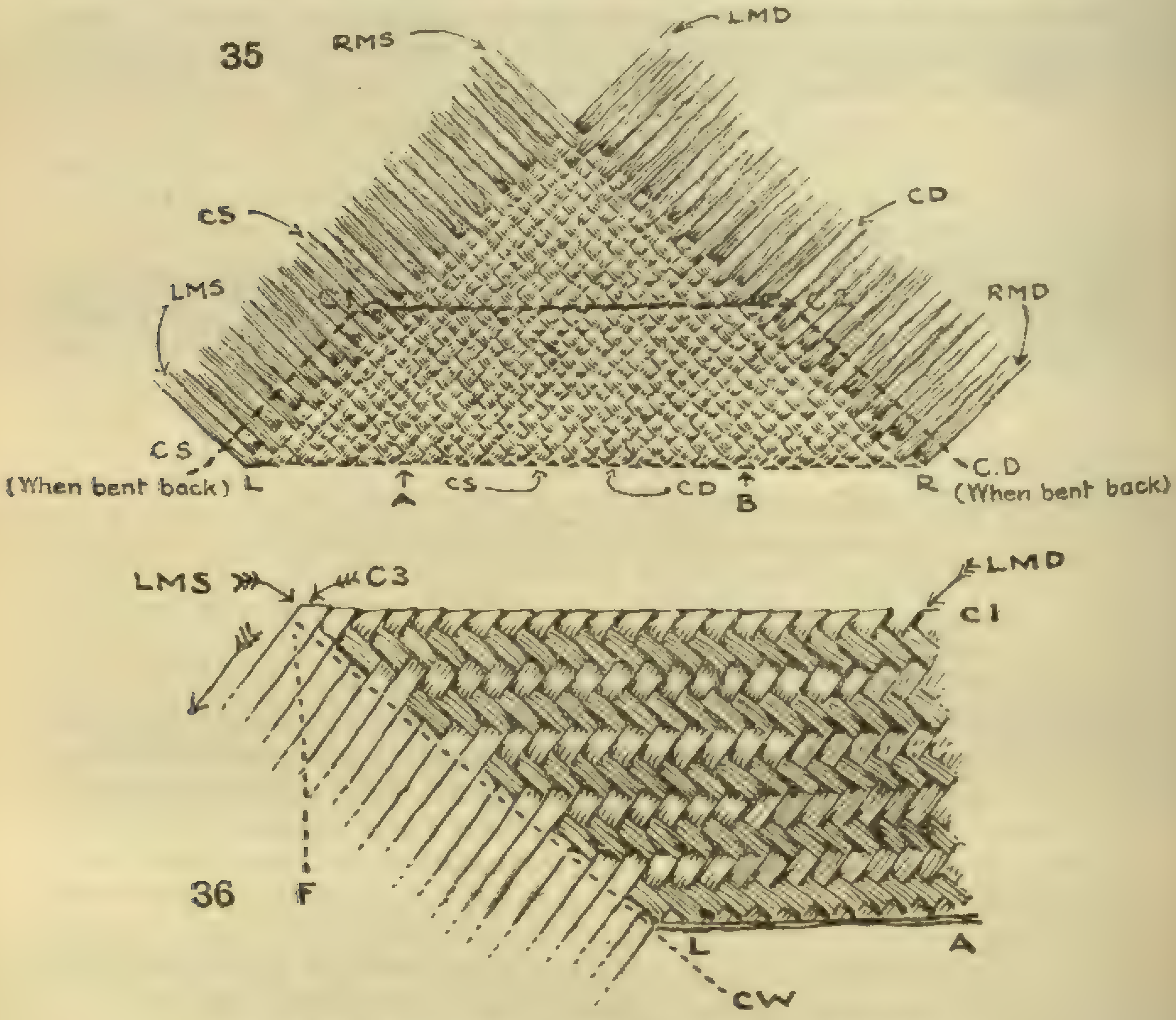
Yours is the small basket of food, mine is the small basket of food,
and our guests will be fed;
Yours is the weapon, mine is the weapon, and our enemy will be routed.

The *poti* (Plate 82, fig. 2) is a four-cornered basket similar in shape and size to the narrow-wefted *kono*. It was used to contain cooked *taro* (*Colocasia antiquorum*) for people of higher rank. Both in deference to the rank of the guest and the quality of the food, better material in the form of bleached white wefts was used. The butt-tufts of the wefts necessitated a different beginning from the *kono*, and the whole construction differed accordingly.

The beginning, like that of the *taka* mat, consists in plaiting a single row of wefts, by means of their butt-tufts, into a three-ply braid of 13 in. to 14 in. in length.

The body is usually plaited in a twilled two. The wefts, along the whole length of the braid beginning, are speedily separated into an upper layer of dextrals and a lower layer of sinistrals. Reference to fig. 35 shows that where the two layers cross one another a triangular area is formed, bounded on the left by the left marginal dextral (LMD), and on the right by the right marginal sinistral (RMS). In this area the two sets of crossing wefts are in position for plaiting, and merely need rearrangement by separating the dextrals with the left hand and placing the sinistrals in position with the right. The plaiting is continued for the depth of the basket, 4 in., till the line C1 to C2 is reached. The first left-hand corner is made at C1, by turning back the sinistral weft (CS) which crosses the left marginal

dextral (LMD) at this point. It will be noted that the plaited portion has been narrowed by the converging wefts, LMD and RMS, from 13 in. at the braid beginning (LR) to 6½ in. at the working-edge (C1 to C2). At the same time that the crossing sinistral (CS) is bent at right angles to its course, the left portion of the work (LA) is bent forwards at right angles, and CS is plaited through the disengaged sinistrals on the left. It comes to occupy the dotted line parallel with LMD. The single layer of disengaged sinistrals to the left of CS, by the bending-forward of the portion LA, have now changed their direction and function as dextrals. The sinistrals to the right of CS continue the plaiting through the original dextrals and the left sinistrals, which have joined them. The inner two of the latter have



Figs. 35, 36.—Methods of making a *poti*, a variety of *kono*.

to be bent in slightly to lie parallel with the left marginal dextral (LMD). By pulling the wefts taut the corner of C1 is defined. As the plaiting proceeds beyond the line C1 and C2, all wefts are bent forwards and downwards at right angles to their previous course. The second corner at C2 is formed by bending back the dextral CD, which crosses the right marginal sinistral (RMS) at this point. The right portion of the plaited work (BR) is also bent forward at right angles, and the disengaged dextrals to the right of CD change direction and function as sinistrals. The crossing dextral (CD) is plaited through them at right angles to its original course, and occupies the dotted course parallel with the right marginal sinistral (RMS).

The dextrals to the left of CD, as the plaiting proceeds, pass through the remaining original sinistrals and the right dextrals which have joined them. The inner two dextrals have to be bent in to lie parallel with the right marginal sinistral (RMS). The tightening-up, as before, defines the first right corner (C2). The plaiting proceeds, and the part beyond C1 to C2 forms the bottom. The sides are also continued by bending the wefts from the bottom surface over at the lines produced forward from the two corners at right angles to the line connecting (C1 to C2). The plaiting continues forward for about 8 in., when the two sides run into the bottom surface through the wefts from the body having no crossing elements to combine with. Fig. 36 shows a side view of the left side of the work. The part of the side completed on the formation of the left corner (C1) was the triangle L A C1. The bottom surface, which of course is not visible, has gone on from C1 to C3. The additional part of the side completed is the triangle L C1 C3. Here the side runs out at C3 because, after crossing the left marginal sinistral weft (LMS), the downward wefts from the bottom surface have no crossing elements to engage. A similar condition exists on the right side, where the right marginal dextral weft (RMD of fig. 35) will run into the bottom surface at a point (C4), corresponding to C3 as C2 did to C1. The points C3 and C4 form the other two corners of the basket. The area between the four corners completes the bottom surface. The corner at C3 is formed by bending back the weft from the bottom surface that crosses the left marginal sinistral (LMS) at C3, and plaiting it through the disengaged wefts to lie parallel with it in the dotted course CW. The wefts from the bottom surface are bent down at right angles at the line connecting the two corners C3 and C4. They continue the end side of the basket, and the appropriate ones follow CW, being bent round to the side as they come below the corner C3 in the dotted line C3 to F. Similarly the side wefts as they reach this line are bent at right angles to engage the wefts in forming the end surface. Similar procedure forms the fourth corner. The changes of direction of the different sets of wefts all fit in, and provide two sets of crossing-elements to complete the end and sides. The plaiting continues until the sides reach the same level as that part bounded by the braided butt-tufts.

The finish is a modified *kopetipeti* called *kopekepeke*. With the basket turned on its outer side we have a lower layer of sinistrals and an upper layer of dextrals. Commencing on the left, the sinistrals are twisted on the outer side of the basket with a half-turn at right angles to their former course, brought diagonally across the upper border, and bent to run downwards and to the right. Fig. 37 shows that the first sinistral (S1), in its new course on the inside, passes over the first dextral it meets (D1), whilst the next dextral (D2) is lifted over it. The first dextral (D1) to reach the edge is now bent over at right angles, and the next sinistral (S2) is twisted over with it. This double weft passes over the first dextral it meets (D2) and the next dextral (D3) is lifted over it. When the dextral D3 is lifted, the sinistral to its left (S1) is twisted upwards at right angles and, passing under D3, continues upwards with it as a double weft. From now on the upward wefts are double, formed of the dextral and the descending sinistral on its left, which is bent upwards as above. The next dextral at the edge (D2) is bent back at right angles and accompanied downwards by the next sinistral (S3). They cross the double weft (D3–S1) and pass under the next dextral (D4), which on being lifted is joined by the sinistral on the left (S2). In the next series from the edge, the double weft (D3–S1)

is bent back with the next sinistral (S4). From now on the down wefts consist of three elements, the double up-weft being joined by a fresh sinistral after being turned at the edge. The triple weft, after passing under D5 with its sinistral addition S3, drops the two older elements which formed the up-weft (D3–S1), whilst the latest sinistral element (S4) is turned upwards with the dextral on the right (D6). It is thus seen that the sinistrals which form the upper edge by covering the dextrals are firmly fixed by having a double zigzag course. The edge is completed on the right by plaiting the last wefts into a three-ply braid and tying it to the end of the plaited butt-tufts. The projecting ends of the wefts are cut off, and loops of twisted flax-fibre may be fixed to the rim on either side as handles.

Satchels, or *Kete.*—*Kete* are divided into *kete tatahi* (open-plaited) and *kete puputu* (closely plaited). The latter are also called *kete pae*. Open-plaited baskets are made from natural wefts, and closely plaited ones from white and dyed wefts.

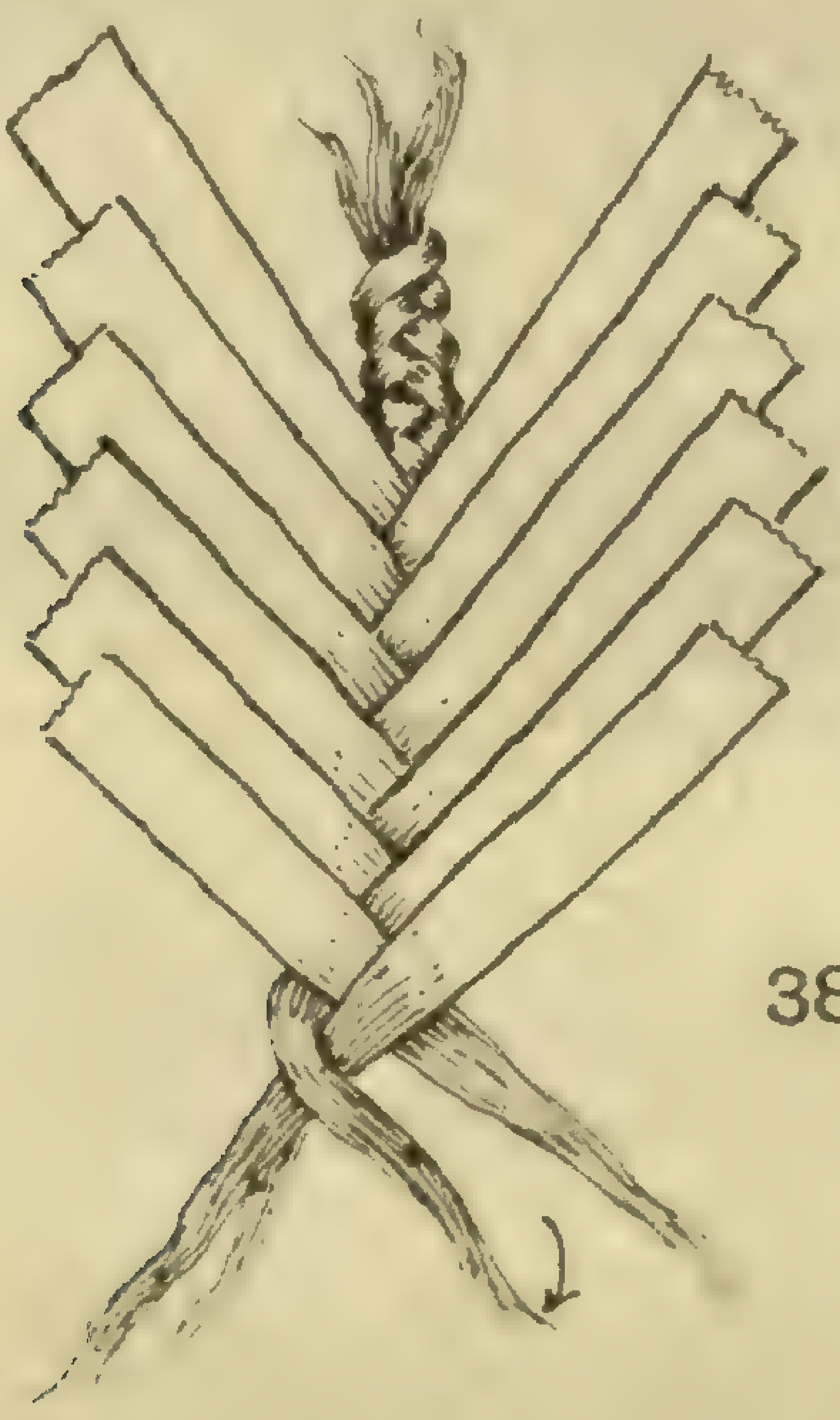
(*a.*) *Kete tatahi* (open-plaited satchels): These are the ordinary rough baskets in everyday use. They are of all sizes, and are used for so many purposes that it is difficult to imagine the Maori being without them. All kinds of food, from *kumara* and *taro* to fern-root and forest berries, were

Fig. 37.—The *kopekepeke* finish of a *poti*.

collected in them. In recent times seed-potatoes were often stored away in special baskets with a wide weft. In gathering shell-fish, baskets with three handles on either side were used, the end pairs for tying with flax around the waist, whilst the middle pair was pulled apart to admit the supplies obtained. This was, of course, in water; and the same was done in some forms of fishing. Dried and cooked *inanga* were stored in them. Food-supplies, on the march, were packed in baskets and carried on the back. *Karaka* (*Corynocarpus laevigata*) berries, after being cooked, were steeped in water in baskets made of *kiekie*. Large calabashes containing preserved pigeon often had baskets plaited round them, and were finished off with long handles for facilitating transport. Kelp bags containing mutton-birds (*Puffinus griseus*) were covered with *totara* bark and the base fitted into a basket. Even the shorter lengths of drift firewood were collected in *kete*, and in the excavation of fosses for their fortifications the earth was carried away in them.

The beginning consists in plaiting the butt-tufts of the wefts in a three-ply, the wafts being added alternately from either side to the ply that goes to the middle. This process, as in the *taka* mat, is called *whiri*. The commencement of the *whiri* is the same as (*b*) and (*c*) in the *taka* mat (pp. 717–18). Fig. 13 shows the butt-tuft of weft 1 crossing that of weft 3 to the middle. In the basket commencement, the tuft of a

fourth weft added on the right is brought over with tuft 1, and as tuft 2 is twisted over them another weft is added on the left, and its tuft brought over to the middle with tuft 2. The addition from either side is continued to the required length of the basket, and the ends of the tufts plaited on, knotted with an overhand knot. The more common commencement, however, is (*c*). Three short pieces of flax are knotted with an overhand knot, and then plaited in three-ply for about 1 in., when the butt-tufts are added alternately on either side to the strand that crosses to the middle position. The crossings are kept from unravelling by the thumb and fingers of the left hand, whilst the right adds the fresh wefts and twists the tufts. On the surface towards the worker the overlapping wefts on either side come close together, but on the under-side the crossings of the butt-tufts show as a thick fibrous cord between the two even rows of wefts (fig. 39).



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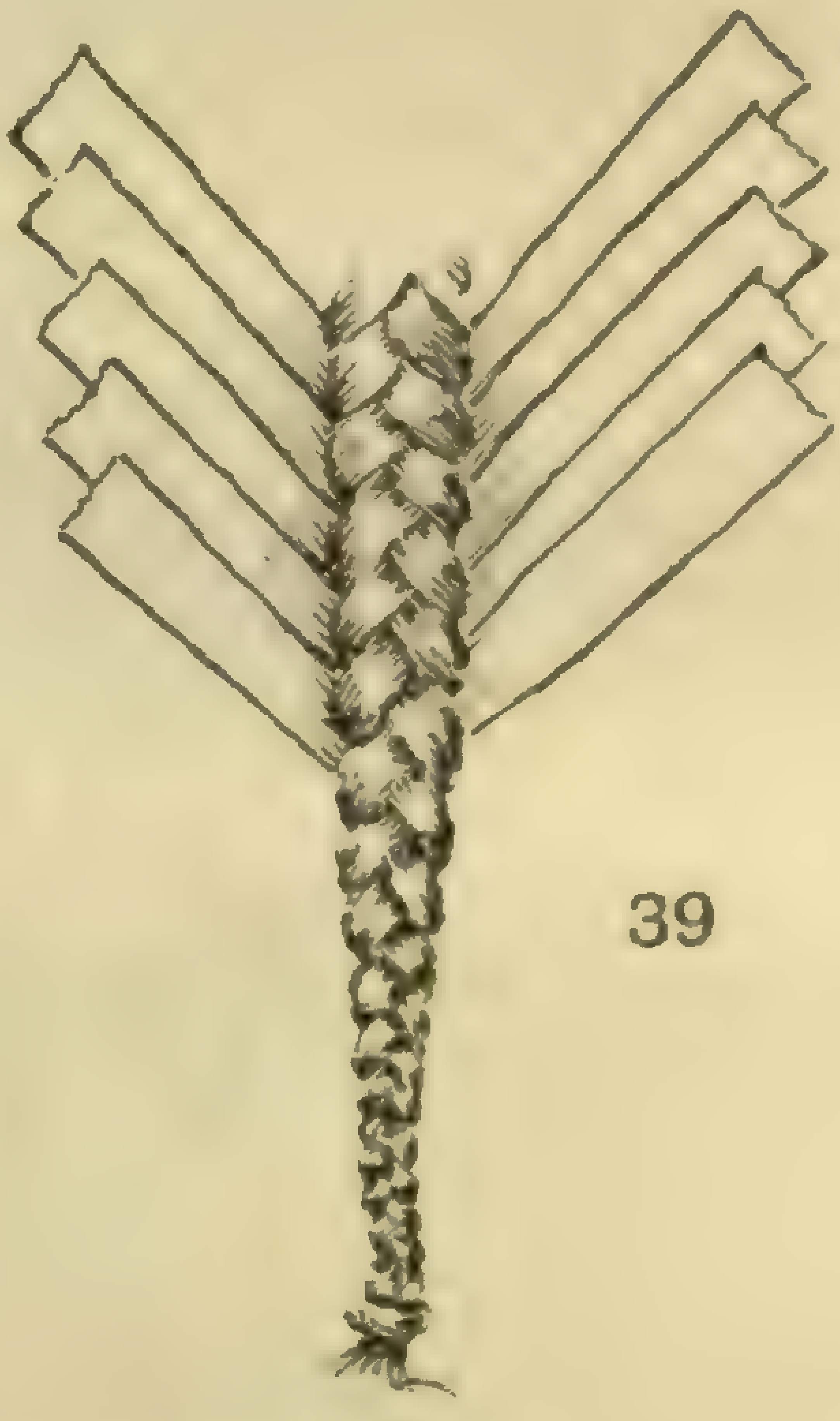

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FIGS. 38, 39.—Laying the keel of a *kete*.

In the smallish-sized basket I am describing, the length of this plaited keel (see Plate 79) is 18 in., the depth in the middle 10 in., at either end 8 in., and the number of wefts on each side is sixty-eight. The wefts in the dry condition average $\frac{3}{16}$ in. in width.

The body in these rough baskets is practically always plaited with a check stroke. Turning the work towards her with the keel lying transversely, the plaiter speedily crosses the alternate wefts close to the keel. Commencing from the left on one side, if the direction of the wefts is towards the right it is obvious that alternate wefts must be bent close to the keel at right angles to their course to provide the sinistral wefts. As in all this work the plaiting proceeds in widths from the left towards the right, the dextrals form the upper layer and the sinistrals the lower. The plaiting proceeds exactly as in the check mats, except that wefts are not turned in to the body at either edge as they pass the marginal crossing weft. Thus a plaited triangle occurs, for the reason described in the *poti* basket. The marginal wefts of the triangle are, in a neat manner, kept from coming loose. If the weft is a dextral, the free end of a sinistral that passes *under* it at the spot likely to become loosened is looped back *over*

it, and the loop passed under a crossing dextral on the plaited portion. A pull on the end of the sinistral disengages the loop when work in this part is to be continued. If the weft to be restrained is a sinistral, then of course a dextral is looped back in a similar manner. This method is also used with a working-edge when work is discontinued for a time.

The work is now turned and the triangle plaited on the other side. The next step is to fill in the space between the triangles which form the ends of the basket. The two sides are bent up so that the raised ridge formed by the plaited butt-tufts is inside. Holding it with the end towards one, it will be readily seen that the disengaged sinistrals from the right side can be brought round to engage the disengaged dextrals from the left side. In this case the dextrals on the left are separated in the usual way and the first sinistral from the right placed in position. The dextrals are reversed and the second sinistral from the right placed between. Continuing this procedure, the gap is filled up (*tutaki*) from the bottom until it reaches the level of the sides. Of course, the wefts are bent round in the vertical line from the end of the keel, but as the material is so pliable this causes no

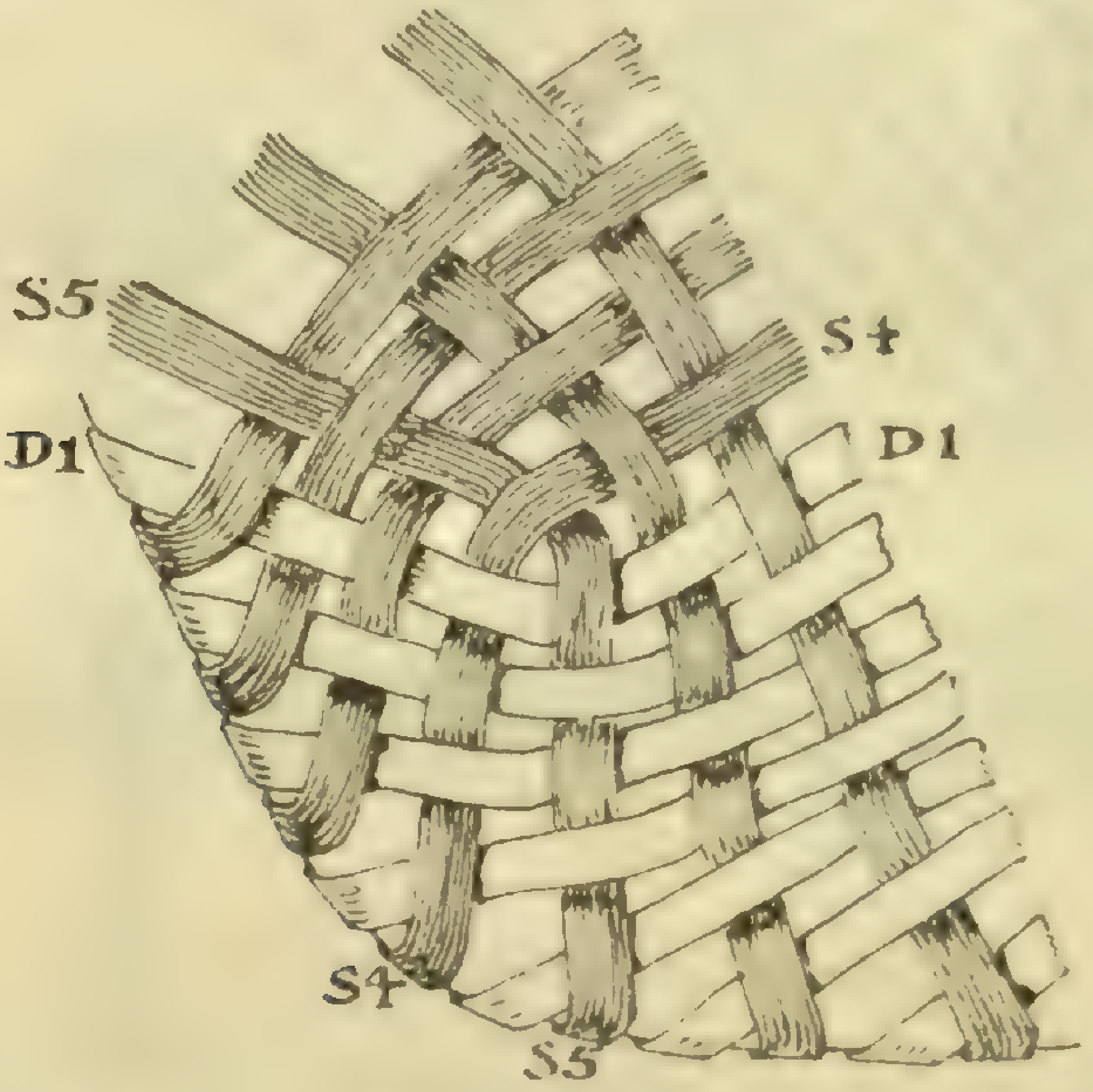


FIG. 40.—Technique of the corner of a *kete*.

trouble. The wefts on each side being equal, they fill up the space naturally, the worker being careful to draw them taut. The other end is done in a similar manner, and the basket is complete except for the finish. This method of dealing with the ends results in a basket with a straight and narrow bottom. The usual method, however, is to make four corners at the bottom. The technique of the corner is shown in fig. 40. Here the left end of the right side is shown with the original sinistrals shaded and the dextrals plain. On the completion of the side triangle the marginal dextral (D1) marked the edge of the completed work. The worker decides on the width for the bottom and selects the appropriate sinistral, in this case the fourth. The fourth sinistral from the end (S4) is accordingly bent back (*ka whatiia*) into the body of the work beyond the marginal dextral (D1), runs parallel with it, and functions as a dextral. The next sinistral to the right (S5) is bent in the opposite direction, and it and the following sinistrals continue to function as sinistrals. The sinistrals to the left of the key weft (S4) follow S4 and function as dextrals. Tightening up S4, S5, and D1 tilts up the left end of the foundation-keel and sharply defines the corner at the crossing-place of these three wefts. The tilting-up

of the keel and the change of direction keeps the sinistrals on the left of the figure close together, although in the diagram they are shown somewhat apart. On the left triangle the same procedure is carried out, but of course it must be the fourth *dextral* that is turned back into the body of the work. The gap is now filled with the disengaged wefts, which have arranged themselves into dextrals and sinistrals. The corners are made at the other end, always remembering that it is the fourth of the series that projects beyond the margin of the completed triangle that is the key weft. If a wider bottom is desired, the fifth or sixth weft may be taken as the key weft; but whichever it is, the same number must be adhered to for all four corners or the basket will be awry and the gaps will not fill in properly (*e kore e tutaki*). In these baskets the keel curves up at each end, making the middle deeper than the two ends (see Plate 80). The depth at the middle is increased by the weight of the contents pulling directly on the handles which are attached to the middle of the upper border.

The finish is made by plaiting the weft-ends with a three-ply plait. The wefts are picked up in fours usually, two dextrals and two sinistrals. Starting usually at one end, the wefts that run in the same direction as the plait are taken together into the lower ply, whilst the other two are bent back and taken into the next ply that crosses it. On reaching the starting-point one of the plies is passed round the first part, and then, rejoining the other two, they are run out in a free braid and the end knotted. This tail is threaded through the side of the basket and the end left inside. Owing to two wefts of the series of four being bent back, holes are left under the braided upper border between the fours. These are useful for threading flax or a rope through to keep in the contents of a full basket. I saw an old lady one morning dropping a single weft from the upper border and then incorporating it farther on, thus making a series of long loops which looked rather untidy. On asking her the reason, she smiled and said, "That is my earmark." Thus one often sees little differences in the plaiting of the upper border, which, if they have no constructional reason, are probably the private marks of careful old ladies for recognizing their property and saving argument.

The handles are put on as the upper border is being plaited. They consist of loops of a three-ply plait of natural wefts about 8 in. long and 4 in. to 5 in. apart where the ends are fixed to the upper border. The upper border is plaited to the middle of the side and the weft material for the handle passed through one of the holes under the border 2½ in. from the middle. The two ends of the handle-material are drawn together, forming a loop round the border, and the wefts divided into three equal parts. The three divisions are plaited in three-ply for 8 in. and then the upper border is plaited on for another 2½ in. The ends of the handle-wefts are now merged with the wefts of the upper border, which is continued on to the other side, where the second handle is affixed in the same manner. In some baskets three or more handles of a similar type are made on each side. These are used in lashing over fern or other covering-material to protect the contents.

Baskets made of cordyline-leaves are made in a similar manner. The wefts are much narrower, but permit of the butt ends being scraped to admit of the *whiri* beginning at the bottom. The completed basket is usually dyed black or considerably darkened by submerging in swamp-mud.

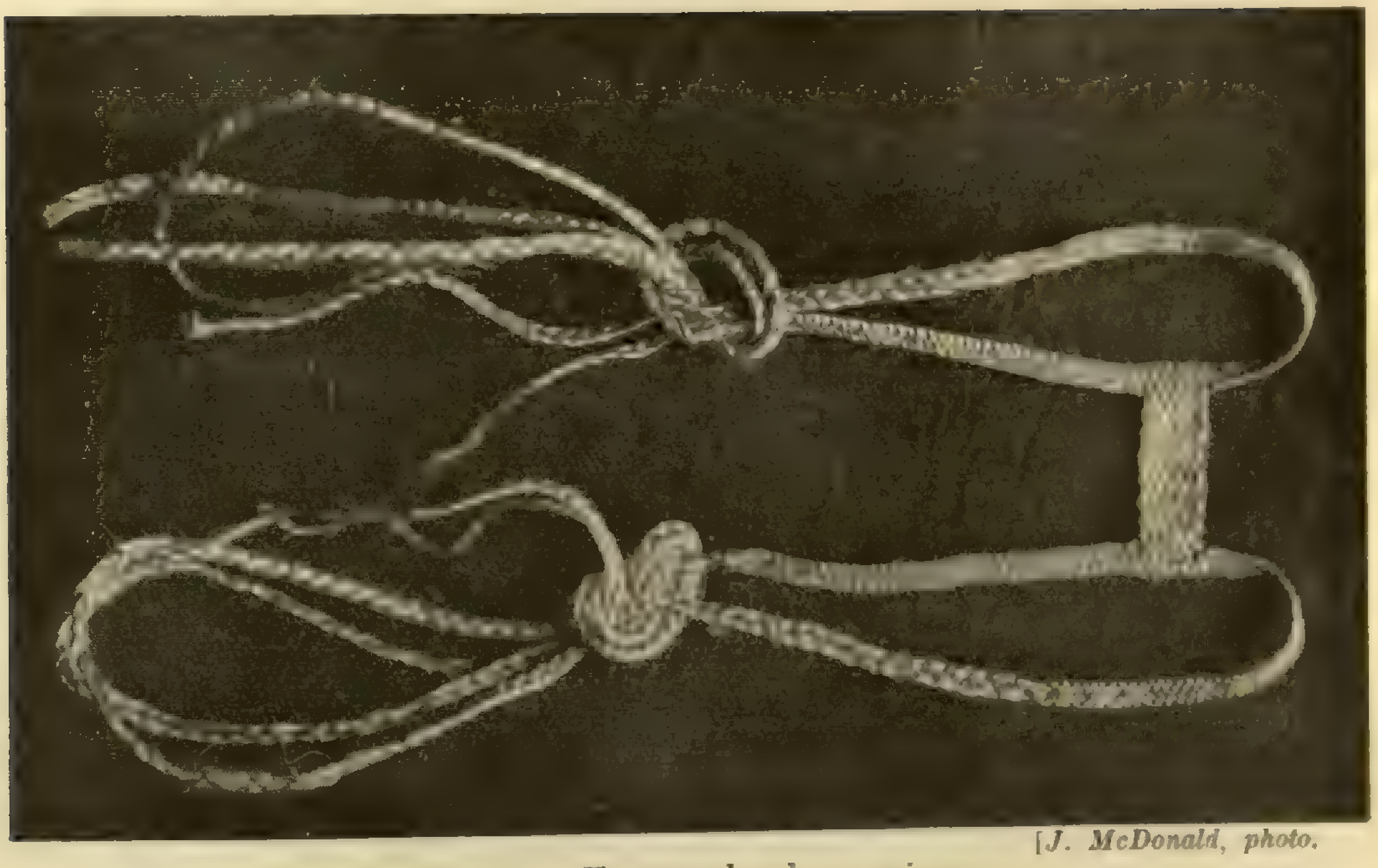
(*b.*) *Kete puputu*, or *kete pae* (closely plaited satchels): This class of basket obtains its name from being plaited closely together and leaving no spaces between the wefts. They were used for containing more valued possessions, and not for rough work. In these days the older women are usually seen carrying a small one to contain their pipe, tobacco, and matches, so that they correspond to the modern civilized woman's handbag for holding her purse, handkerchief, vanity-box, and cigarette-case. Prepared wefts in white and black are used, and another generic name for the class is *putea*. They are made in all sizes. Plain white baskets are made with the same twilled stroke throughout, or plain designs are worked by changing the stroke. Geometrical designs in black, white, and yellow had full play. In some cases the entire basket was made of black wefts, and in others diagonal bands of white, running in the same direction or crossing, were made by introducing four or six white wefts at regular intervals along the keel. White baskets in a similar way were made with narrow diagonal bands of black or yellow. Some were made entirely of *pingao*, and the wefts being narrow resulted in a neat golden-coloured basket. By plaiting the foundation-keel with every alternate weft black and the others white, or making all the sinistrals one colour and the dextrals another, the entire surface of the basket could be covered with coloured designs in zigzag lines, triangles, and lozenges. Owing to the smaller surface, neater work and a greater variety of design was possible than in the *porera* mats. In the earlier days of colonization the making of these baskets was one of the principal sources of income to the womenfolk, and they vied with one another in plaiting complicated coloured designs so as to command a readier sale. They were freely hawked about the towns, but nowadays the few remaining skilled workers have to be sought out and a special order placed in order to obtain them. As in the case of the *porera* mats, the coloured wefts formed an essential part of the structure of the basket; whereas in the Polynesian baskets I have seen, from Niue Island, the coloured elements are overlaid, as in the case of their mats. The various coloured designs must be postponed for treatment with those of the *porera* mats. A splendid assortment of these baskets is figured in Hamilton's *Maori Art*, vol. 4, plate 44.

The beginnings, in the district under discussion, consist of two forms:—

(*a.*) The *whiri* beginning, as in the case of the open-plaited baskets, consisted of plaiting the wefts into a three-ply braid, with the difference that the wefts were added in pairs instead of singly. For the same length of keel there was thus double the number of wefts. This resulted in the close plaiting that distinguished it from the other class. Care was also exercised in eliminating enough of the narrower butt ends to ensure the wefts being of even width throughout their working-length.

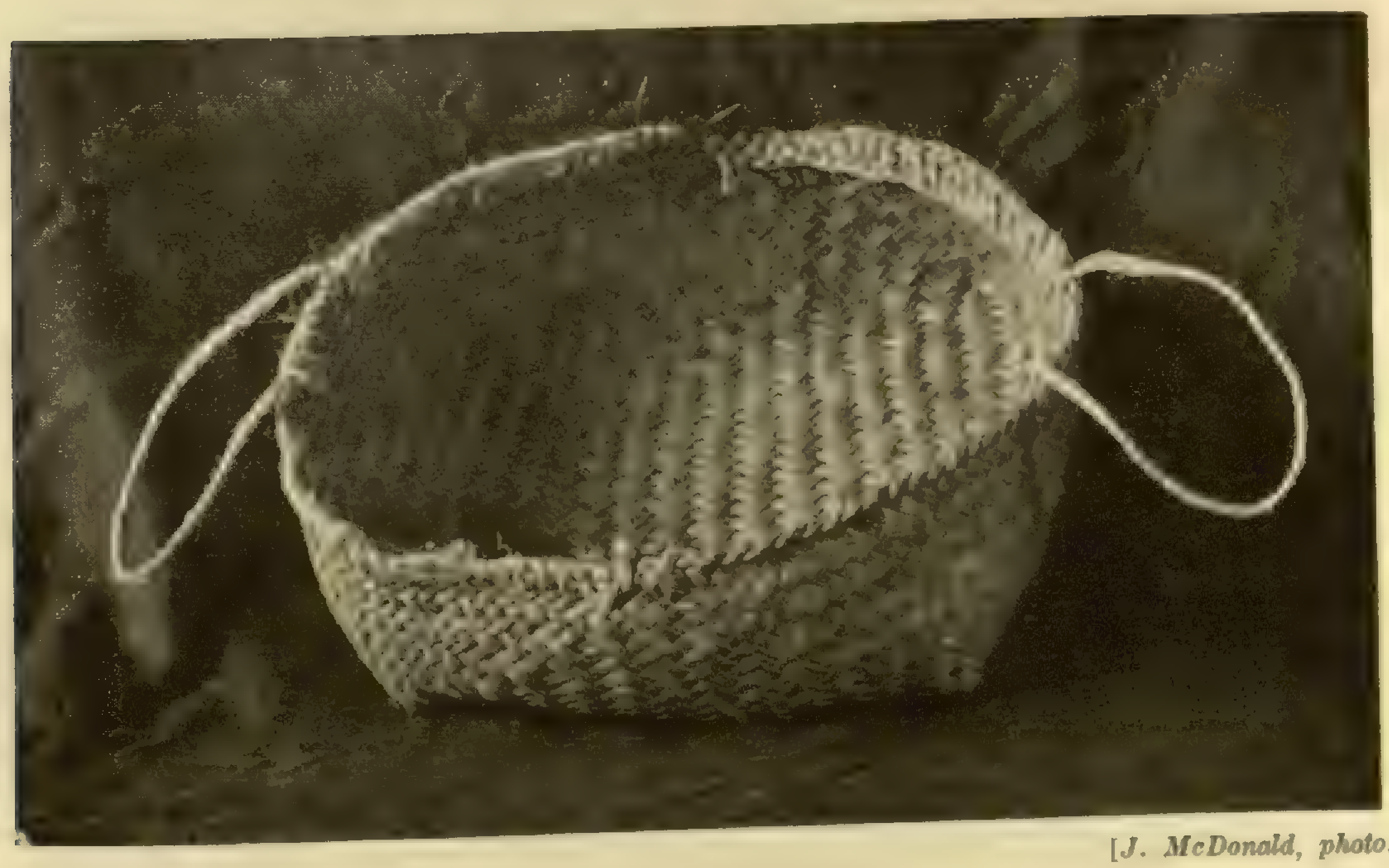
(*b.*) The *porera* beginning was used with some of the baskets whose whole surface was covered with coloured designs. The undivided butt portions were used to lock the beginning-edge, and the wefts were interlaced and divided into dextrals and sinistrals. All the coloured butt portions pointed in one direction and the uncoloured in the other. This beginning was plaited for twice the length required for the keel.

The body of the basket, after the *whiri* beginning (*a*), was plaited in exactly the same manner as in the rough baskets, but the stroke was usually a twilled two. Some were plaited with a check stroke throughout, and others again with combinations of check and twill. The geometrical patterns involved the introduction of twilled threes, fours, or fives. The



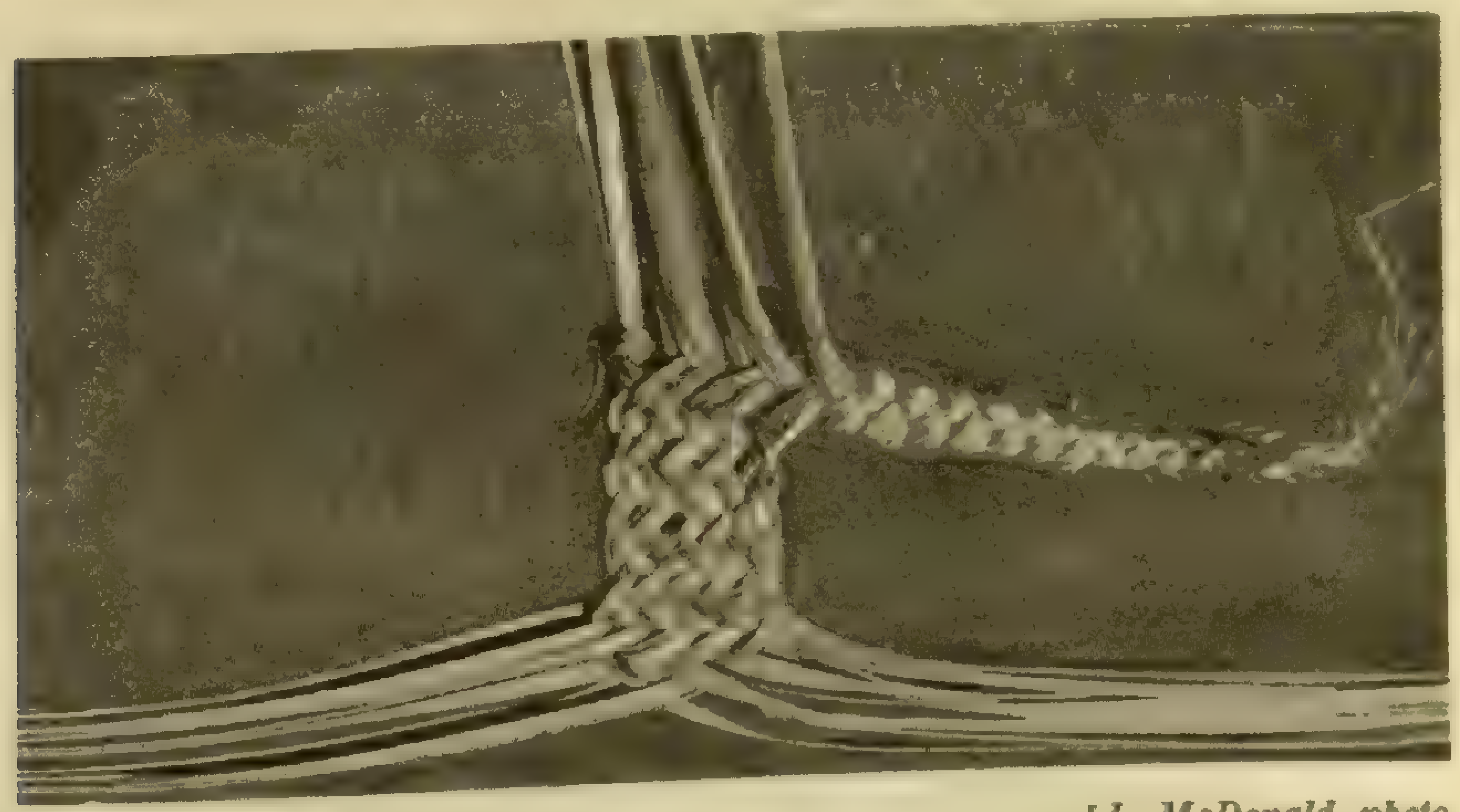
[J. McDonald, photo.

FIG. 1.—*Kawe*, or burden-carrier.



[J. McDonald, photo.

FIG. 2.—*Poti*—four-cornered basket for containing cooked *taro*.



[J. McDonald, photo.

FIG. 3.—*Kawe*, showing start of plaiting.

Face p. 736.]

plaiting of the side triangles, the filling-in of the ends, and the formation of the bottom corners were the same as before.

With the *porera* beginning (*b*), a *whara* or section was plaited to the depth required for the basket, as if making a *porera*, but at the ends the disengaged wefts were left free. The two ends were then brought together and the disengaged sinistrals of one end were interplaited with the disengaged dextrals of the other, in exactly the same manner as filling in the ends of the rough baskets. The sides and ends of the basket were thus completed, leaving a fringe of weft-ends at the upper border and a fringe of undivided butt portions at the lower. No bottom corners were made.

The finish, at the upper border, was made in four ways :—

(1.) *Whiri toru:* The weft-ends were plaited in three-ply, but more carefully and neatly than in the rough baskets.

(2.) *Whiri tuamaka:* This was a four-ply plait at the upper border which made a rounder plait and gave a neater finish than the three-ply.

(3.) *Kopetipeti,* or *kopekepeke:* As already described in the section on mats.

(4.) *Whakakitaratara:* This finish results in the upper border having a serrated appearance, from the wefts being plaited into a series of triangles with the apices upwards. The usual working-number of wefts to each

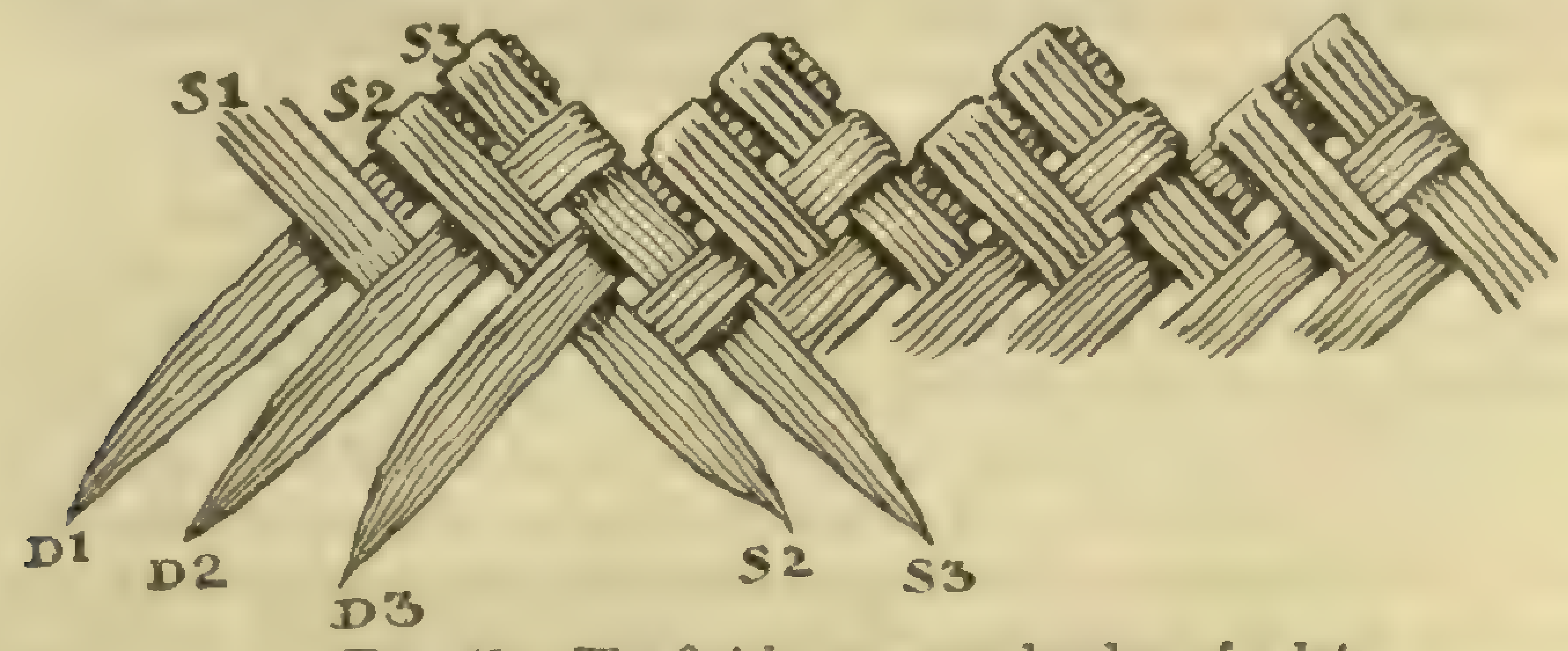


FIG. 41.—The finish, or upper border, of a *kete*.

triangle is three sinistrals and three dextrals. The plaiting is done on the inner surface of the basket, and commences from the left. The first dextral (D1) is looped by bringing the end back on its own course. The first sinistral (S1) crosses above the doubled first dextral. The second dextral (D2) is also looped, and the second sinistral passed through its loop, passed under, round, and over the doubled first dextral, and back along its former course over the second dextral, and then under both parts of the third dextral (D3), which is looped. The third sinistral (S3) passes over the third dextral, through the loop of the second dextral, through the loop of the first dextral, back over the returning part of the first dextral, through the loop of the second dextral again, and over the third dextral. The ends of the first and second dextrals and the second and third sinistrals are drawn taut, and the triangle sharply defined (fig. 41).

The free part of the triangle really consists of these four wefts, as the other two assist in the formation of the bases of the triangles on either side. Thus reference to the above figure shows that S1 corresponds to S3 in the previous triangle, and D3 to D1 in the following; or, as the Maori instructress said, "The third weft in this tooth will form the first weft in the next tooth." The triangles having being completed round

the upper border, the upper layer of dextral wefts are secured by a three-ply plait, whilst the under layer of sinistrals, which is more secure, is cut off evenly without further plaiting.

One or more rows of these serrations were often plaited on the body of the basket for ornamentation. These were innovations; but the old women maintained that the *whakakitaratara* finish at the upper border is ancient. It is the common finish of Niue Island baskets.

The *porera* finish is given to the baskets commenced with the *porera* beginning. The upper border is finished in any of the above four ways. The basket is then turned inside out and finished at the bottom by splitting the undivided butt ends into their component wefts and joining the wefts of the two sides in a modified *porera* join.

The handles are made of prepared flax-fibre twisted into a two-ply cord. One end is looped through the upper border of the basket, whilst the other end is tied in a knot over the border. In some cases this end is simply passed from the outside through an interspace between the wefts and knotted on the inside, making a very weak finish.

(3.) *Burden-carriers* (Kawe).

The *kawe* consists of two long plaited bands connected by a cross-band at the middle, and is used for carrying burdens on the back (Plate 82, fig. 1). It really belongs to the section on belts and bands, but is of such extraordinary interest as to merit special treatment.

White wefts of flax are used in the construction. The method of beginning is the same as in baskets. The butt-tufts are plaited with a three-ply plait, with wefts on either side to form a keel. The wefts, however, are placed in pairs with the under surfaces in apposition, so that the white upper surfaces may show on either side of the bands. The stiff-leaved varieties of flax are not so good, and the *wharariki* (*Phormium Cookianum*) is the best kind. In the *kawe* I watched being made, six double wefts were plaited in on either side. The ends of the last butt-tufts were plaited on into the usual tail, as in baskets. Each double weft was then split into two with the thumb-nail, making twelve double wefts on either side. The wefts were ½ in. in width. The twelve double wefts on one side were then plaited with a twilled-two stroke into a band 2½ in. long. The width of the band at the plaited base of butt-tufts was 1¾ in., and this width was maintained throughout by turning the wefts back into the body of the band by a half-twist which turned up the surface of the other weft. In some *kawe* the wefts are turned in by merely bending them without changing the surfaces, as in the side edge of floor-mats. This does not make such a smooth edge as the twist. Having reached the desired length of 2½ in., the wefts are divided into two lots of six. The six wefts on the right are plaited through to the left, and continued on in a narrower band at right angles to the first part. Owing to the turns at the edges, it is now only ⅝ in. wide, and is continued on for about 17 in. The remaining unplaited portions of the wefts, of about 18 in., are tied together temporarily to prevent unravelling. The other six wefts are now plaited in a similar manner in the opposite direction and tied. It will be observed that at this stage the two bands are in the same straight line, with an absolutely straight even outer edge, so that they form one continuous band with two unfinished ends. The twelve double wefts on the other side of the keel are dealt with in exactly similar manner, so that we have made two long narrow bands with unfinished ends, joined together at the middle by a band 1¾ in. wide and 5 in. long.

The finish to the ends is done with dressed flax-fibre (*muka*). The unplaited weft-ends are untied, and divided into three equal parts of two wefts each. To each part a 3 ft. length of fibre is attached by looping the thicker end and incorporating the short portion with another weft-division. The three compound divisions of fibre and weft-material are then plaited on in the ordinary three-ply plait so as to produce a somewhat flattened cord. Note that the bending-back of a short length of fibre in another division and plaiting it down for a few strokes absolutely fixes the junction of fibre and weft, and allows it to stand the strain of heavy weights without becoming loosened. As the weft-ends become thinner and give out, the band changes from a flat band to the ordinary fibrous cord. This cord thins down until it is tied in a knot about 3 ft. from its junction with the wefts. The tail of plaited butt-wefts is doubled back and forwards over the middle of the connecting-band, and tied down to it by strips of fibre passed over the plait and through the plaiting on either side of it.

A burden is carried with the *kawe* in the same manner as a soldier's knapsack. It corresponds to what are called in this country swag-straps. The *kawe* is laid on the ground with the two bands parallel, and the burden is placed across the mid-part by the connecting-band. The two bands are brought over the burden and tied in loops loose enough to allow of the arms being inserted between the band and the burden. The connecting-band prevents the long bands slipping off the sides of the burden. The act of tying the fibrous ends of the bands is known as *tui*. The carrier usually sits down in front of the burden with his back to it, puts his arms through the loops, and is usually assisted to his feet by a pull on the arms. Failing assistance, the burden with the *kawe* in position is usually placed on something to raise it from the ground. From this we get the old proverb, *Tuia te kawe, tairanga te kawe, ooi ko te kawe o te haere* (Fasten the *kawe*, lift up the *kawe*, ah ! it is the *kawe* of departure). This denoted readiness to depart on some project, whether on a military expedition or some more peaceful object.

The bands for encircling the loads were 8 ft. or 9 ft. long. Some were made much broader than that described. The flat band made it more comfortable for the shoulders, and the fibrous ends made the tying easier and firmer. The connecting-band in the middle prevented the long bands from slipping over the sides of the burden. Altogether, the *kawe*, with its simple but ingenious construction, was admirably suited for its purpose.

Burdens were carried on the back by women, commoners, and slaves. In the frequent war-expeditions extra provisions had to be carried on the back, and this necessitated a fair number of porters. It was the lack of transport facilities when departing from the coast that restricted military operations until the season when food was plentiful in the enemy country.

The point of extraordinary interest in the *kawe* is that it forms one of the increasing number of differences that are coming to light between the Maori and the rest of the Polynesians. Throughout eastern and western Polynesia the method of carrying burdens is by means of the balance-pole, so commonly seen amongst Chinese gardeners and porters. In Samoa, Tonga, and Niue it is to be seen in everyday use. In Niue men, women, and even children may be seen coming in from their plantations with a load of bananas, plantains, yams, or taros suspended at each end of a pole carried across one shoulder. In eastern Polynesia, from the Hawaiian Islands down through the old distributing-centre in Tahiti and Raiatea, on to the Maori nearest of kin, the Rarotongan, and away to the islands

farther east, the balance-pole is in universal use. In New Zealand it is entirely absent. That the old-time Maori was acquainted with it a study of the words connected with that form of transport would seem to indicate. The Polynesian root word for carrying on the shoulder is *amo*. In the Samoan dialect *amo* means "to carry on the shoulder," and the name for the balance-pole is also *amo*. A burden is *amoga*. In Tongan, *haamo* is to carry on the shoulder burdens suspended from each end of a stick, and the burden carried as above is *haamoga*. In western Polynesia the Polynesian *ng* sound is represented by the letter *g*. In Niuean, to carry on the shoulder is *hahamo*, and the balance-pole is *lakau hahamo*. The Niue dialect has more aspirates than the Maori, as indicated in such words as *uha*, *mohe*, and *tahi*, which have the same meanings as the Maori *ua* (rain), *moe* (sleep), and *tai* (tide or sea). In Hawaiian, to carry a burden on the shoulder is *amo;* the burden so carried is also *amo;* and the balance-pole is *auamo*. In the Marquesan and Mangain dialects *amo* also means "to carry on the shoulder," and in the Moriori dialect of the Chatham Island *amo* is "to carry on a pole." Returning to New Zealand, in the Maori dialect *amo* means definitely "to carry on the shoulder." In his *Comparative Dictionary* Tregear gives as one meaning of *amo* "to carry in any manner," and quotes as an example, "*Amo ake au i taku toki nei.*" The phrase certainly means "to carry an axe," but if any Maori were asked how the axe was carried he would unhesitatingly reply, "On the shoulder." The literal meaning of the phrase is, "I carry up on my shoulder this my axe." Similarly, if a piece of firewood is carried on the shoulder the word *amo* is used. If firewood is carried on the back the word *waha* is used. To ask a man to shoulder his axe by using the words "*Me waha to toki*" would be quite wrong. There is a special word for shouldering, which is *amo*. Another Maori word for carrying on the back is *pikau*. *Waha* and *pikau* refer exclusively to carrying on the back, *hiki* to carrying in the arms, and *amo* to carrying on the shoulder. The Samoans have a similar word for carrying on the back, *fafa;* whilst the Tahitians use *vaha* and the Hawaiians *waha* with a similar meaning. The two methods of carrying are here distinguished by different words; but in Samoa and Tahiti *fafa* and *vaha* apply more to carrying persons on the back than ordinary burdens.

It is clear from these comparisons that, though the balance-pole does not now exist amongst the Maori, they have preserved in the word *amo* and its present meaning the old original use of the word. But, in addition to this, we have a trace of the survival of the old use of the word as applied to the balance-pole itself. For the transport of sick or wounded men, and also of the dead to their last resting-place, a litter or rough stretcher was made of two poles, which were carried on the shoulders of two men. One name for the litter was *kauhoa*, but equally common names were *kauamo*, *whataamo*, and *amo* without any prefix. Whilst the litter itself was called *amo*, there can be no doubt that to use the word *amo* in connection with the act of carrying, the shoulder had to be associated with it. Maori stretcher-bearers, carrying the wounded on the ordinary military stretchers during the late European War, when they wanted to give their arms a rest would say "*Me amo*," and the handles of the stretchers were unhesitatingly hoisted up on to their shoulders. "*Me amo*" meant "Let us shoulder it." Sometimes, when time pressed and material was not immediately available, a wounded man was slung to a single pole carried on the shoulders. Furthermore, heavy burdens of food were often carried in this

way. In the story of Wairangi, carefully written-down verbatim from a tattooed warrior of the old school, mention is made of large eels being carried on a pole held horizontally on the shoulders of two men. In more modern times a pig was often carried in this manner. To this the term *amo* was applied. Hence we see that the pole and the shoulder are associated together naturally in the mind of the Maori.

What better evidence can we get in these days to support the fact that the balance-pole was known to the Maori at some period of his past? How came it to be abandoned? Dr. Brigham, in explaining the use of the notches on the ends of the *auamo*, or Hawaiian balance-poles, gives what seems to be the key to the problem in New Zealand. In comparing the Hawaiian *auamo* with the Chinese bearing-stick, he points out that the latter "is without notches, though one or two pins were inserted to answer the same purposes as notches. It is easy enough to keep the suspended baskets from slipping off in the flat country of China or most Chinese towns, but the Hawaiian had to climb most difficult paths in his native islands, and *it would often be impossible to carry the pole perfectly horizontal.*" The italics are mine. Let us consider the paths the Maori had to climb in his native islands. We know that the Maori dwelt on fortified hilltops. The forts on the flat, protected by stockades, were so comparatively few as to be not worth consideration. The steeper the hill, the better for defensive purposes. These hills were terraced, so that, in addition to their natural steepness, the communication between successive terraces was rendered artificially steeper. The cultivations for *kumara*, *taro*, and gourds were on the flats below. Fish and shell-fish from the rivers, lakes, and sea, birds, berries, roots, and all food-supplies, firewood, and water had all to be carried up the steep hillsides and through narrow, tortuous, and still steeper communication-ways between tiers of terraces, embankments, and palisades to their homes. The balance-poles, with burdens fore and aft, would be the worst possible means of porterage. Where the Hawaiian in his own land found it "*often* impossible to carry the pole perfectly horizontal," the Maori in ascending the paths to his hill fort would find it *always* impossible; and no notch or even hole could do away with the disadvantages of the balance-pole. New conditions with insuperable difficulties led to the abandoning of the ancient method of carrying burdens. The balance-pole could not survive in Maori New Zealand. This in itself is sufficient to account for the introduction of a new method. The Maori had sufficient mentality to cope with the situation and evolve the *kawe* without outside assistance.

There are, however, so many things peculiar to the Maori as distinguished from the rest of Polynesia that there is a growing opinion amongst New Zealand ethnologists that these seeming anomalies are derived from a wave of pre-Maori people with Melanesian characteristics. Mr. Elsdon Best—than whom no one has gone into the matter more deeply—considers that, apart from the difficulties in the way of the balance-pole, the finding of a better method was rendered easy by accepting that already in vogue amongst the *tangata whenua*, or pre-Hawaiki and pre-Toi people. It is now accepted in most quarters that when Toi and his grandson Whatonga came from eastern Polynesia, two centuries before the Hawaiki migration, the country was fairly thickly populated. Both before and after this latter colonizing wave, also from eastern Polynesia, war was waged against the *tangata whenua* by the eastern Polynesians and their allies by intermarriage. Some tribes of the latter were exterminated, and others driven out of the

country, to find a temporary haven of peace in the Chatham Islands. Many of the men were spared to become slaves, and many of the women were taken in marriage. In fact, though all the tribes of the present day proudly trace their ancestry back to canoes from Hawaiki, we know that the crews of those canoes were comparatively few in number, and the blood of the *tangata whenua* tribes enters in some cases very largely into the existing tribes. Of the people absorbed, a large proportion must have been women, as very few are recorded in the passenger-lists of the famous Hawaiki canoes. Though the eastern Polynesians, by their higher mentality and aristocratic and warlike character, must have imposed their higher culture upon the resultant race, the bulk of the menial tasks in the cultivating of food and carrying of supplies into the hill forts must have fallen upon the slaves and womenfolk. What more natural, then, as Best suggests, than that they should carry the burdens for their lords and masters in their own way—namely, on the back by means of the burden-carriers, or *kawe*. The obvious advantages of the *kawe* over the balance-pole would be so apparent that the *amo* would speedily be relegated to the limbo of things forgotten, but the name, with its original meaning, remained as a memory of the past. Judge Maning describes, in *Old New Zealand*, a dilemma that occurred to the last canoe setting out on an expedition. When the food-supplies were to be transported down to the canoe it was found that all the slaves and commoners had departed in the other canoes. Not one of the chiefs or warriors could carry food on his back, and a catastrophe was only averted by a bright mind suggesting the brilliant idea of carrying the burdens down in their arms. Thus was the *tapu* avoided. May there not be some trace in this of the early clash of two systems? The proud and aristocratic eastern Polynesians, whilst allowing slaves, commoners, and women to adopt the new method, disdained to use it themselves, and *perhaps* perpetuated their conservative prejudice through succeeding generations by extending the anatomical boundaries of *tapu* from their sacred heads to their burden-rejecting backs. *Ko wai ka mohio.*

Acknowledgments.

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ART. 46.—*An Introduction to Maori Music.*

By JOHANNES C. ANDERSEN.

[*Read before the Wellington Philosophical Society, 19th July, 1921; received by Editor, 20th July, 1921; issued separately, 18th June, 1923.*]

Plates 83–85.

THE few references to Maori music in the writings of early voyagers and early residents in the country do not assist much in enabling a conclusion to be arrived at as to whether the Maori had any definite system of music —that is, whether music had with him become a conscious art. The appreciation of melody, except as mere accompaniment, was apparently in the earliest stages of its development: that is, the Maori did not consciously appreciate melody for its own sake—there was no tune existing separately apart from words. He appreciated a song chiefly because of what the words conveyed; the tune, or *rangi*, was altogether secondary.

There is nothing in early writings to help us to determine if the Maori was conscious of definite intervals, except the fact that tunes were known and remembered—tunes, too, that to European ears seemed destitute of melody. There is nothing at all to help us to determine if he was conscious of definite ratios between the intervals employed—to determine if he used any kind of scale.

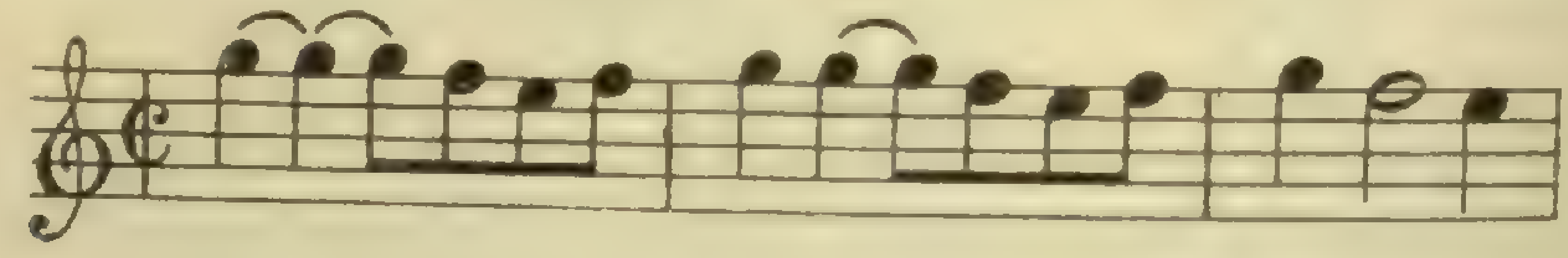
So little did Maori music, as a rule, appeal to Europeans that the great majority of writers declare that he had none. Most of them admit, however, that he had an extraordinarily keen sense of rhythm — rhythm in movement and in song. When a number of Maori are gathered together there is certain to be song, and the most casual listener can hardly fail to be impressed by the fact that rhythm is the element of greatest appeal. It does not enter into all the songs: some are quite without it, some have it in parts, some are rhythmical throughout. It is especially in the song accompanying the dance that the sense of rhythm is most manifested. There it is extraordinary in its perfection—extraordinary because so perfectly observed by a large number in unison. The rhythm is very often on the point of becoming metrical, and often actually is metrical.

It seems needless to quote, or even to refer to, the many unfavourable remarks on Maori music by the various early voyagers and visitors to New Zealand; they are too often quoted to be given fresh prominence here. One or two appreciative remarks may, however, be quoted to show that a very few were keenly alive to the fact that the Maori did possess a genius for music, even if that music was ill understood because so different from that to which the observers were accustomed.

The following invaluable remarks were made by Forster in 1774, published in 1777 (vol. 2, pp. 476–78):—

"Peeterré returned on shore with his comrades in the evening, but came to sell us fish again the next day. We frequently heard him and the rest of the natives singing on shore, and were sometimes favoured with a song when they visited us on board. Their music is far superior in variety to that of the Society and Friendly Islands; and if any nation of the South Sea comes in competition with them in this respect I should apprehend it to be that of Tanna. The same intelligent friend [? Burney]

who favoured me with a specimen of the songs at Tonga-Tabboo, has likewise obligingly communicated to me another of the New Zeeland music, which will be sufficient to give an idea of the taste of the people. He did not visit the island of Tanna, but assured me that there appeared to be some display of genius in the New Zeeland tunes, which soared very far above the wretched humming of the Taheitian, or even the four notes of the people of the Friendly Islands.



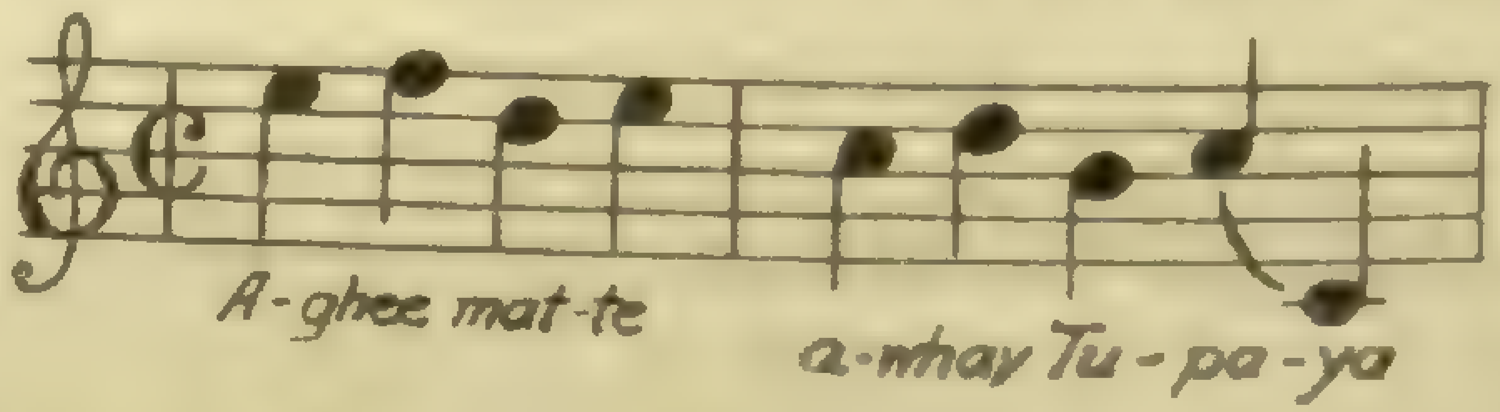
"Of this tune they continue to sing the two first bars till the words of their song are at an end, and then they close with the last. Sometimes they also sing an underpart, which is a third lower, except the two last notes, which are unisons.

"The same gentleman likewise took notice of a kind of dirge-like melancholy song, relating to the death of Tupaya. This song was chiefly practised by the inhabitants round Tolaga Bay, on the northern island, where the people seem to have had a high regard for that Taheitian. There is an extreme simplicity in the words, though they seem to be metrically arranged in such a manner, as to express the feelings of the mourners, by their slow movement.

āghēē, māttĕ ăwhāy Tūpāyā !*

Departed, dead, alas! Tupaya!

"The first effusions of grief are not loquacious; the only idea to which we can give utterance is that of our loss, which takes the form of a complaint. Whether the simplicity of the tune is equally agreeable, or well judged, is a question which I cannot pretend to determine. The connoisseurs in music must acquit or condemn the New-Zeelanders.



"They descend at the close from C to the octave below in a fall, resembling the sliding of a finger along the finger-board on the violin. I shall now dismiss this subject with the following observation, that the taste for music of the New-Zeelanders, and their superiority in this respect to other nations in the South Seas, are to me stronger proofs, in favour of their heart, than all the idle eloquence of philosophers in their cabinets can invalidate. . . ."

Cook's remarks in 1770 are of less value, because less detailed (vol. 3, p. 468): ". . . in their song they keep tune with such exactness that

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* It is not known what is the significance here of the signs for long and short, – and ⌣, since the notes given are all the same length.

I have often heard above a hundred paddles struck against the sides of their boats at once, so as to produce but a single sound, at the divisions of their music. . . . A song not altogether unlike this [a war-dance and song] they sometimes sing without the dance, and as a peaceable amusement. They have also other songs which are sung by the women, whose voices are remarkably mellow and soft, and have a pleasing and tender effect; the time is slow, and the cadence mournful, but it is conducted with more taste than could be expected among the poor ignorant savages of this half-desolate country; especially as it appeared to us, who were none of us much acquainted with music as a science, to be sung in parts. It was at least sung by many voices at the same time. . . . They have sonorous instruments, but they can scarcely be called instruments of music: one is the shell, called the Triton's trumpet, with which they make a noise not unlike that which our boys sometimes make with a cow's horn; the other is a small wooden pipe, resembling a child's nine-pin, only much smaller, and in this there is no more music than in a pea-whistle.* They seem sensible, indeed, that these instruments are not musical, for we never heard an attempt to sing to them, or to produce with them any measured tones that bore the least resemblance to a tune." . .

It cannot be known how nearly the tune given by Forster reproduces the original—whether it actually does so or whether it merely gives the nearest notes of our scale: if the latter, it is, of course, practically valueless for the purpose of acquainting us with Maori music, since its distinguishing characteristic is lost.

Not until 1855 is the question of scale touched on at all. A letter by J. H. Davies, of Trinity College, Cambridge, "On the Native Songs of New Zealand," is printed as Appendix I to Sir George Grey's *Polynesian Mythology and Maori Legends*, 1855 (ed. 2, 1885). In this letter he analyses the Greek genera of scales, of which he notes three kinds—the diatonic, the chromatic, and the enharmonic. The diatonic genus consisted of a minor half-tone, a major tone, and a major tone ascending: this gives four notes, a tetrachord; and the tetrachord repeated gave the complete diatonic scale. This scale had a modification by which, while it retained the same semitone, it contracted the next tone and extended the last. The chromatic genus consisted of two tetrachords of semitone, semitone, and tone and a half. The enharmonic genus consisted of quarter-tone, quarter-tone, and two tones.

He supposed the enharmonic to be the scale used by the Maori, and he gives four tunes in enharmonic notation, making the following proviso (Grey, 1885, pp. 235–36): "I here beg to state that, though with great care and the assistance of a graduated monochord, and an instrument divided like the intervals of the Chinese kin, I have endeavoured to give an idea of those airs of New Zealand which I have heard, yet so difficult to discover the exact interval, that I will not vouch for the *mathematical* exactness; neither will I pledge myself not to have written a chromatic for an enharmonic interval, or *vice versa*. I must also, in justice to myself, add, that the singer did not always repeat the musical phrase with precisely the *same* modulation, though without a very severe test this would not have been discernable, nor then to many ears; the general effect being to a European ear very monotonous. . . ."

* The instruments referred to would appear to be a *pumoana* and a *nguru*: no mention is made of the *koauau*.

Mr. Davies's essay is much fuller in the first edition than in the second. Whilst the singer may not always use exactly the same modulation, the Maori are quick to detect any slight deviation from the recognized tune. The writer has heard two singers rehearsing a song, to be sung in unison. Quarter-tones were used freely; and more than once one stopped the other, saying, "No; that's not quite right"—when the phrase would be repeated, the difference being hardly, if at all, discernible to the writer, though the Maori would say, "Yes, that's right," on the phase being sung to his satisfaction.

It must be remarked that the notes of the songs given by Davies do not all conform to the enharmonic scale, the lower tetrachord of which, on the tonic A, is as under:—

The various accidentals employed in the notation of Maori music are represented by the following signs, of which those marked half-sharp and half-flat are the ordinary sharp and flat of European music:—

𝄲 = quarter-sharp; ♯ = half-sharp; 𝄰 = three-quarter sharp;
𝄳 = quarter-flat; ♭ = half-flat; 𝄭 = three-quarter flat.

In the full scale, built of two tetrachords—the Dorian enharmonic scale—a tone separated the highest and lowest notes of the respective tetrachords:—

It will be seen that in the songs recorded by Davies the wide intervals may contain intermediate notes, and that consequently the scale, whilst it may be enharmonic, is not the Greek enharmonic scale. Both the chromatic and enharmonic scales were eventually supplanted by the diatonic. In Maori music there are, as a rule, few wide intervals, and quarter-tones enter freely in all parts of the melody. Maori music resembles Greek in the following respects: instrumental music was mainly an accompaniment of the voice; the rise and fall of the melody corresponded more or less with the natural tunes of speech; harmony, if present, was quite rudimentary.

The writer, after hearing many Maori songs and many pakeha-Maori songs, came to the conclusion that there was only one way by which the scale employed by the Maori of old, if any were employed, might be detected. There was at least one musical instrument in common use among the old-time Maori upon which definite intervals were produced—the *koauau*. As it has been repeatedly said by the Maori that there were no tunes without words, presumably the intervals on the *koauau* would correspond with the intervals used in singing.

The *koauau* was an instrument of the flute kind, and was made of wood or bone (see Plate 83, figs. 1, 2, 3, and Plate 85, figs. 1–4). Like the flute, it was pierced on the side with holes, in number from one to six,

the most usual number in instruments that have been preserved being three. The great difference between the *koauau* and the flute is in the method of producing the sound. The present-day flute has the embouchure, or hole to which the lips are set, in the side, and the breath is blown across the flute, the hole at the top being plugged. The *koauau* was like the Egyptian nay in having both ends open and in having no side embouchure, the sound being produced by blowing across the open upper end. Polack says of their flutes " . . . the sounds elicited from them are very unharmonious. They differ in shape and size, some possessing three, four, and five holes, to emit the sound, and are generally worn round the neck . . ." He gives five roughly-drawn figures (Polack, vol. 2, pp. 172–73). Cruise, however, notes (pp. 211–12) that " two chiefs came on board ; one of them wore a carved flute, or pipe, round his neck, upon which he played the simple but plaintive airs of this part of the island, with much correctness." (*See* Hamilton, fig. 1, pl. 57, p. 417 ; fig. 6, pl. 58, p. 419.)

The writer has met with no Maori able to produce music from the *koauau*, and has never seen a *koauau* in the possession of a Maori. It was only by repeated experiment that he was able to sound some of those in the Dominion Museum collection ; many of the small bone *koauau* have remained obstinately mute. In April, 1923, he heard a Maori air played by an aged man, Iehu Nukunuku, at Waiomatatini. The flute was not a *koauau*, however, being made from a piece of gas-pipe about 12 in. long, the three holes being at the lower end. The sound was produced in the way learned by experiment, save that the Maori blew sideways across the opening instead of directly. He did not use the natural low-sounding notes, but the octave above, as in the English pipe ; and, whilst sweet in sound, the mellowness of the wooden *koauau* was absent. The opportunity has been taken for inserting this and other information obtained since the reading of the paper.

Seeing that the English pipe has but three holes, and is blown from the end, it was thought that, as the scale is produced on the pipe by overblowing and cross-fingering, so it might be produced on the *koauau*. The writer has been unable, however, to overblow the *koauau* ; it will speak only in its natural notes : the pipe, which is much longer than the *koauau*, the holes being towards the extreme end, speaks in the upper octave. No octave can be produced on the *koauau* ; six consecutive notes comprise its compass, the range being no more than two and a half tones. Moreover, there is great diversity in the size and shape of the *koauau*—so great that it is difficult to see how any uniformity of sound could have been obtained from the various kinds. They differed in length and the shape of the bore, in the number of holes, and in the distances between the holes as well as in the size of the holes. Some had a hole at the back as well as those in the front. Colenso writes, " Those for the mouth were differently formed from those for the nose," but does not say in what way they differed.

Whilst at Rotorua in April, 1920, the writer was with one of the *kaumatua*, or elders, of Ohinemutu—Kiwi-amohau—and from him, through Mr. Elsdon Best, obtained some particulars as to the construction and playing of the *koauau*, though the instructor was himself unable to produce music from the instrument.

Usually, he said, the *koauau* was the length of the forefinger ; and when the lower end was pressed down against the extended thumb and laid along the forefinger the top hole was opposite the top joint of the finger, the second hole opposite the second joint, and the third opposite

the third joint—approximately at the junction of the line of life and the line of head. So far as concerned the *koauau* we had with us, the position of the holes agreed fairly well with the finger-joints, as he said; but reflection must show that this arbitrary method of measurement would necessarily result in irregularity: forefingers differ in the proportions the phalanges bear to one another; and even did they not differ, this means could apply only to the *koauau* of three holes. On being asked if there were definite recognized proportionate distances between the holes he said No; the fingers first told in playing if the holes were in the correct positions, then the ear told if the notes were correct in sound. (More must be said of this later.)

The general term for the holes was *wenewene.* In playing they were either quite covered or quite uncovered; there was no half-covering to produce intermediate notes. There were none but the four simple notes produced by means of the three holes. The top hole was *te mea whakangawari* (the means of softening the sound); the middle hole was *te mea whakakaha* (the means of strengthening the sound); the bottom hole "corrected" the sound of the others—whatever that might mean. Playing the notes in sequence up and down was called *kai hi.* There was no hole at the back, except occasionally a hole through a lug for suspension of the *koauau* round the neck; always three in the front, except in the nose-flute, which had an extra large hole for the nostril just below the top. In the nose-flute the three holes were smaller.

The *koauau* we had brought to Rotorua was conical in bore, the narrower part downward. This, he said, was intentional; "that is why it sounds well." The size of the end apertures bore no definite ratio one to the other—that is, no measured ratio—"the eye of man controlled these things."

Human bone made the best *koauau;* its sound was better. When wood was used, it was generally *whau* (cork-wood: *Entelea arborescens*).

Two or more flutes might play in concert, but always in unison; or three like instruments might similarly play together—the *koauau,* the *putorino,* and another whose name he had forgotten. All played the same tune, but each had its special quality of tone.

All tunes had words; there were no tunes without. One or more people might sing to the sound of the *koauau,* but softly, so that the sound of the instrument might not be lost, and the words and the sound of the flute both be heard. The tune played in unison by Tutanekai on the *koauau,* and by his friend Tiki on the *putorino,* conveyed certain words to Hinemoa, telling her the course of action she was to adopt in leaving her people and coming to him across the lake from Mokoia. Kiwi said that no person then living at Ohinemutu had seen the *putorino* played, and no one now heard the *koauau.* Captain Mair, living in the same village, said that about dusk, from almost every house in the *kainga,* could be heard the soft sounds of the *koauau;* "but that was long ago," said he; "now you never hear it at all." It was dusk as he spoke—a romantic hour at that romantic spot: the island Mokoia shadowy in the distance across the glimmering lake, and musical Maori voices and laughter coming from the neighbourhood of the many steaming pools and springs. Instead of the sounds of the *koauau,* the writer more than once heard, in the evenings, the sounds of its supplanter, the brass fife.

The particulars obtained from Iehu Nukunuku correspond in some respects with those obtained from Kiwi-amohau. The *koauau* was the

length of the forefinger. The position of the lowest hole was at the tip of the forefinger when that finger was laid on the flute, back upwards, so that the end of the flute touched the second joint. The finger was then pivoted on its tip until its back rested on the flute; the first joint then showed the position of the second hole, the second joint that of the top hole. The top hole was the width of the thumb from the top aperture. In the nose-flute (the *koauau whakatangi ihu*) the top hole was the width of the forefinger from the top aperture; the second the width of the thumb from the first; the third the width of the first and second fingers from the second.

The *koauau* was usually played in the evening, the experts often sitting on a special platform, where mats (*whariki*) might be spread for them, the people sitting round about the platform listening. Should a player start his music at night when the people were asleep, any one waking up would stay awake to listen, because the sounds were so pleasing to the ear. Iehu agreed that there was no tune without words; as he put it, "there was no aimless playing of the *koauau*." When he himself played, a note was sounded for every syllable, so that one could almost hear the words, "especially," as one remarked, "if you knew the song."

Much of this information was obtained without questioning, the old man being a storehouse of lore, and very clear in his remarks. Another elderly man, Riwai Miringaorangi, remarked that the three holes, counting from the top, were known as Maui-mua, Maui-roto, and Maui-taha—three of the Maui brothers. Te Rangitaotahi was a famous player of the Ngati-Porou of the olden time; he lived perhaps twenty generations ago.

The *koauau* was made also of *tutu* or *houhou*, the hole being made by laying a red ember on the central pith, and gently blowing, causing the ember, renewed from time to time, to sink through the wood.

The sound of the *koauau*, when played either with the breath of the lips or the breath of the nose, carried to a considerable distance, for all its softness. The distance between the home of Hinemoa, on Mokoia, and Tutanekai, on the land-shore of the lake Rotorua, was about a mile and a half, and at Hiruharama, or Jerusalem, on the Wanganui River, the writer was told that the sound of the *koauau* could be heard as far as Aorangi—an old pa, of which now nothing remains but part of the trench and earthworks and a few lonely graves—on the top of a hill a mile distant down the river.

Kiwi-amohau said that Tutanekai played the *koauau* whilst Tiki played the *putorino*. Grey reverses this, however: "*Ka huihui raua ko tona hoa ko Tiki, na he putorino ta Tutanekai, he koauau ta Tiki*" ("Tutanekai and his friend Tiki sat together, Tutanekai with a *putorino*, Tiki with a *koauau*") (1885, p. 128, Maori part). When Hinemoa asks him what is to be the signal for her coming to him, he says, "The sound of the *pu*." "*Ka mea a Hine Moa, 'He aha te tohu mo taku haerenga mai?' Ka mea a Tutanekai, 'E tangi he pu i nga po katoa, ko ahau tena, hoe mai.'*" ("Then said Hinemoa, 'What shall be the signal for my coming to you?' Then said Tutanekai, 'The sounding of the *pu** in the nights; that will be I; paddle to me'") (p. 129). Later on it says, "*Na, no te turuawepo, ka piki a Tutanekai raua ko tona hoa ko Tiki ki runga ki te raua atamira; i reira ka tango tetehi ki te torino, ko tetehi ki te koauau*" ("Then in the quiet night Tutanekai and his friend Tiki mounted to their platform; there the one played on the *torino*,

* *Pu* (? short for *putorino*): Williams gives *pu* as meaning pipe, tube, flute.

the other on the *koauau*" (p. 129). Hinemoa heard the sound, and, since the canoes had all been drawn high up by her suspicious people, she started to swim towards the island whence it came. She rested, when "*ano te rangi o te koauau a Tutanekai*" ("again the melody of the *koauau* of Tutanekai" (p. 130), where Tutanekai is given the *koauau* instead of the *putorino*—unless it simply means that the composite sound of both instruments was regarded by her as coming from Tutanekai. Even then there is a suggestion that it was the *koauau* that produced the melody; and the suggestion is of value.

The writer, through Mr. Elsdon Best, questioned Iehu regarding the two instruments used, and he remarked that it was Tiki who played both; Tutanekai was not able to play either. This was a ruse adopted in other instances: so much was a player on the *koauau* appreciated that a lover would sometimes charm his mistress by proxy. Sitting in the dusk or dark, the player would be beside him; but should the fire brighten the playing would cease. No doubt some unpleasantness might follow when such wooing proved successful. Iehu said that Tutanekai gave his sister to his friend as a reward for his services. This is not given as the reason in the tale, and no doubt the Arawa would have something to say on the subject.

It is difficult, however, if not impossible, to gather fact from legend, and it is perhaps indiscreet to attempt to do so. It is equally difficult to separate fact from fiction in information concerning matters of this kind derived from living men.

The *koauau* upon which the details above were based happened to have a conical bore, the holes happened to coincide with the finger-joints, and the length happened to be the length of a forefinger. The flute is, however, modern; many, modern and old, do not conform with the requirements above as regards bore, length, or distance between the holes. Nevertheless, *koauau* are known in which one or more holes, when pierced, have failed to please the ear of the makers, for they have been plugged, and others pierced. Details of two are given below. These "attempts" prove two things: firstly, that there were no recognized definite distances between the holes, or at least that were there such they were unknown to the makers of the altered flutes; secondly, that there were certain intervals that pleased the ear, certain that displeased it. The conclusion appears to be that the Maori was "feeling" for the intervals, unconsciously it may be, as he was feeling for melody. When a *rangi koauau* was composed, the *rangi*, or air, would evidently have been made to conform with the intervals of a certain *koauau*; it is evident that the intervals on the *koauau* were not made to conform to definite intervals of singing, since the intervals on the various *koauau* do not correspond. On the other hand, it must be noted that in wooden *koauau* the first and second holes are relatively much closer than the second and third, as if some proportion were observed, even though such proportion were indefinite.

There is a fine carved *koauau* in the Dominion Museum, Wellington (Plate 83, fig. 1). It is in the shape of a double-headed phallus, and is undoubtedly old. On showing it to old Maori men they take it, look at it closely, glance at one another, and remark as they hand it back, "That is an old one." The measurements of this *koauau*, which gives a clear, mellow note, are as under. The outside diameter is perhaps of no significance, though it may be remarked that in a spurious *putorino* bought in London and now in the Dominion Museum the sides are so thin

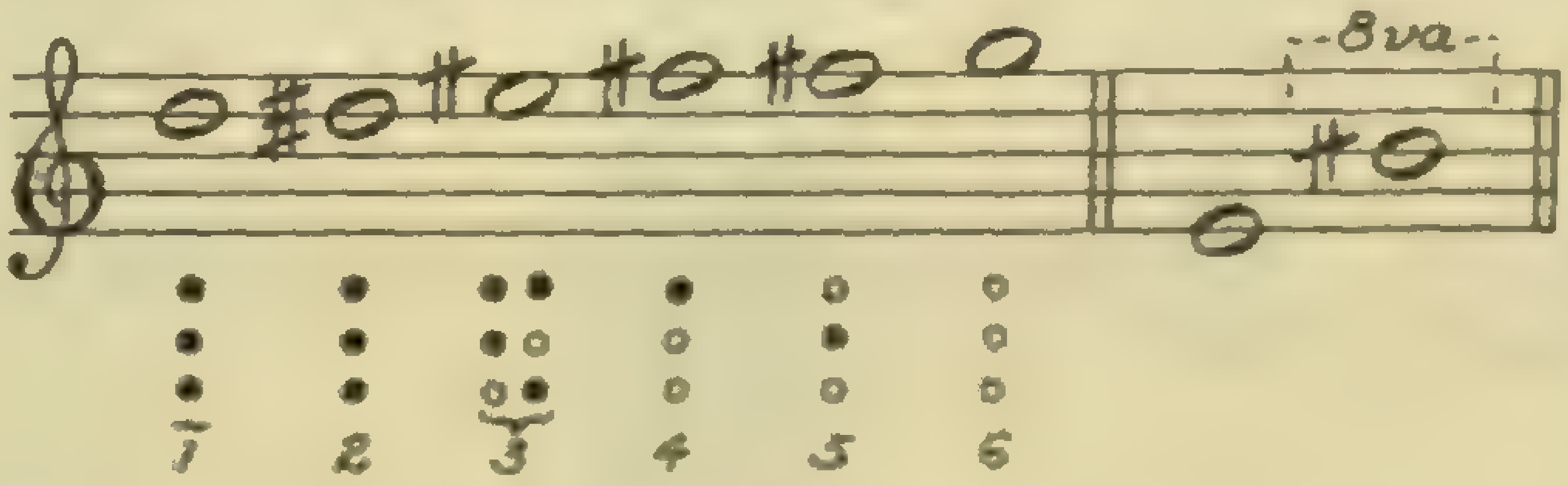
that they vibrate strongly, whereby the quality of the note must be affected. The piercing of three additional holes has been begun, evidently at a comparatively recent date : the top one is barely begun ; the bottom two have penetrated only a short distance into the thick wood ; so that the three original holes are fortunately the only ones through which the instrument speaks. The distances of the holes from the top of the instrument are given below, also those of the holes commenced, and the distances between the holes.

1. *Koauau* in Dominion Museum, No. 1679.

Length, 194 mm. ; diameter, 45 mm. ; bore—top 20 mm., bottom 22 mm.

From top to			Distance from Hole above.
	1	.. .. 29 mm.	
1	2	.. .. 53 mm.	24 mm.
2	3	.. .. 76 mm.	23 mm.
3	4	.. .. 113 mm.	37 mm.
	5	.. .. 145 mm.	32 mm.
	6	.. .. 165 mm.	20 mm.

The larger numerals are the speaking holes; the small include the holes partly pierced. The two diameters would appear to indicate that the bore is slightly conical, the wider end being at the bottom ; but, as the lower opening is slightly belled, the bore is practically uniform through nearly the whole of its length. The following notes are obtainable :—



It is very difficult to be absolutely sure of the intervals, for the reason that the pitch may be varied through the interval of a tone according as the blowing is more or less transverse ; the pitch is lowered if the blowing is less transverse—that is, if it is more directly down on the edge of the tube than across it. The blowing is changed as the aperture is more or less covered by the lower lip. The above pitch was taken on a pitch-pipe, but the actual pitch of any particular note is not so important as the actual interval between the various notes. The first note, D, is obtained by covering the three side holes and partially covering the aperture at the lower end with the little finger. This partial covering will also flatten any note sounded. The second note, D $\frac{3}{4}$ sharp, is obtained by removing the little finger from the lower aperture, but keeping the three side holes covered ; the third by keeping the upper two holes covered ; and so on, as in an ordinary unkeyed flute or fife. In the fingering indicated above the dark circles are covered holes, the open circles uncovered holes ; the stroke beneath the first indicates the little finger across the lower aperture. The first note and the fifth would possibly not have been used ; on other *koauau* the fingerings 4 and 5 produce the same note, 5 being, perhaps, the slightest shade higher than 4. It would nevertheless be natural for a player to extend the range of the instrument by any means in his power.

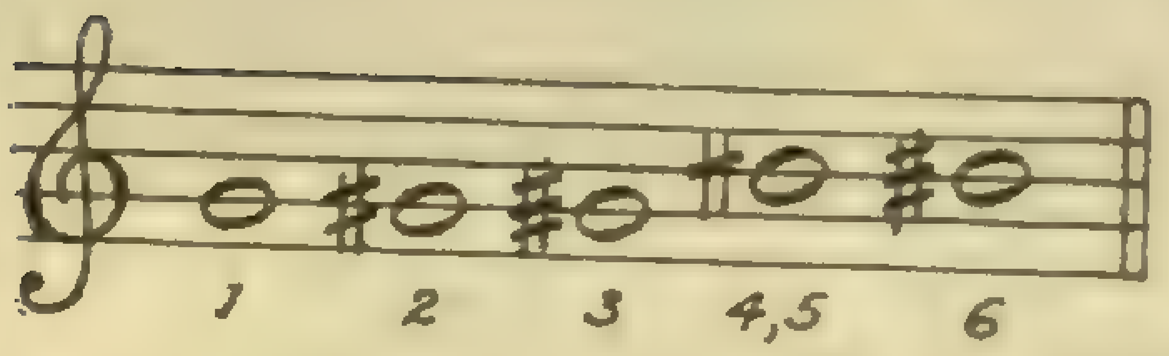
The six notes cover an interval of two and a half tones. Intermediate notes may, of course, be obtained at any time by only partially covering the holes, or more easily by blowing more or less transversely—it is, indeed, difficult to avoid a slight sharpening or flattening of a note in the transverse blowing. The two notes following the six are produced by blowing with all holes covered, and the lower aperture also closed with the palm; the second note is overblown, and it is only by closing the lower aperture that the *koauau* can be overblown at all. The overblown note is the same if all the side holes are covered or if the two lower ones are uncovered; it is raised if all three side holes are uncovered. These two notes would never be used in ordinary playing.

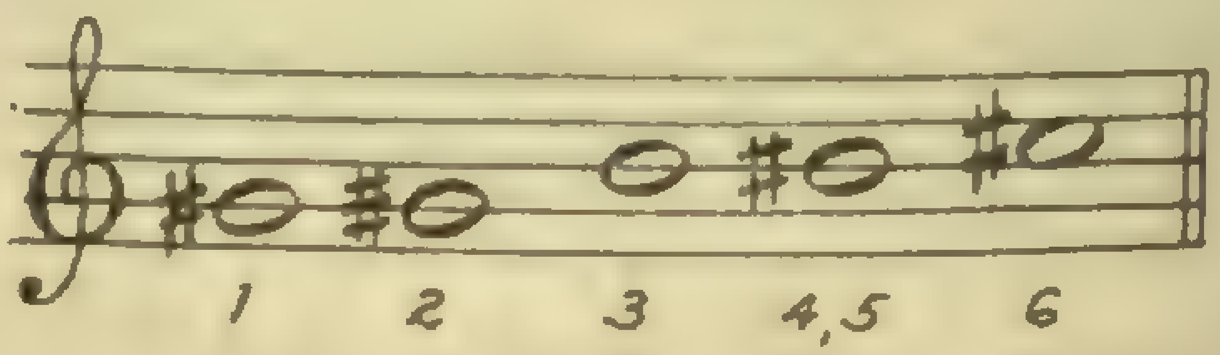
This particular *koauau* has been selected for examination because of its undoubted age and genuineness. The dimensions and notes of more modern *koauau* are given for comparison :—

2. *Koauau* belonging to Ven. Archdeacon H. W. Williams.

Length, 146 mm. ; bore—top 22 mm., bottom 16 mm.

		Distance from Hole above.
1	20 mm.	
2	41 mm.	21 mm.
(Trial)	79 mm.	
3	88 mm.	47 mm.





3. *Koauau* in Otago University Museum, No. D 21/58.

Length, 151 mm. ; bore—top 17 mm., bottom 16 mm.

		Distance from Hole above.
(Trial)	27 mm.	
1	32 mm.	
(Trial)	52 mm.	
2	58 mm.	26 mm.
(Trial)	65 mm.	
3	94 mm.	36 mm.
(Trial)	100 mm.	

These two are of particular interest because they have plugged trial-holes, showing that the maker was not satisfied with the intervals first obtained. In 2 (Plate 83, fig. 2) there were two trials for the lowest hole; in 3 (Plate 83, fig. 3), there were two trials for both the top hole and the lowest, and three for the middle hole. *Koauau* 2 is shown to be modern, apart from the fact that it is known to be so, by the plugging of the trial-hole with sealing-wax. Over the top and middle holes small pierced circles of *paua* shell have been countersunk. *Koauau* 3 looks modern, and the intervals, after the repeated trials shown by the plugged holes, approach those of the European scale. No diameters are given for these two, as they are torpedo-shaped.

One of the *koauau* in the British Museum, (Plate 85, fig. 1) shows two plugged trial-holes.

[Photo. J. McDonald.

FIG. 1.—Wooden *koauau* in Dominion Museum, Wellington.
FIG. 2.—Wooden *koauau* in possession of the Venerable Archdeacon H. W. Williams, Gisborne
FIG. 3.—Wooden *koauau* in Otago University Museum, Dunedin.
FIG. 4.—Bone *koauau* (?) in Otago University Museum, Dunedin.

1 2 3 4 5 6

Figs. 1–5.—Wooden *putorino* in British Museum.
Fig. 6.—*Pumoana* in British Museum.

FIGS. 1–4.—Wooden *koauau* in British Museum.
FIG. 5.—Wooden *nguru* in British Museum.
FIG. 6.—Bone *koauau* (?) in British Museum.
FIG. 7.—Stone (?) *nguru* in British Museum.

Taking the old *koauau*, No. 1, as a standard, then supposing Nos. 2 and 3 to be made the same length, their holes should be separated by the distances below :—

Hole	No. 1.		No. 2.		No. 3.	
	Mm.	Difference. Mm.	Mm.	Difference. Mm.	Mm.	Difference. Mm.
1	53	..	27	..	41	..
2	76	23	54	27	75	34
3	113	37	117	63	121	46

Or, supposing the holes to be pierced at the same proportionate distances in *koauau* Nos. 2 and 3 as in No. 1, they should be as under :—

Hole.	No. 1.	No. 2.	No. 3.
1	53	40 instead of 20	41 instead of 32
2	76	57 ,, 41	59 ,, 58
3	113	85 ,, 88	88 ,, 94

The one point of similarity is that holes 1 and 2 are nearer together than holes 2 and 3. There can be no agreement of intervals in the tone when the intervals between the holes are so divergent. It is probable that, as different people pick out different colours in the spectrum as more pleasing to their eyes, so different people pick out different tones in the harmonics as more pleasing to their ears : this is evident from the fact that different scales are adopted by different peoples ; nor is any disadvantage obstrusive until the sense of harmony is awakened, when harmonic colour is gained only at the expense of melodic colour.

It is possible to play some of these *koauau* as nose-flutes ; the Ven Archdeacon Williams tells me that No. 2 above was so played by the old man by whom it was given to him. The *koauau* is held with the hole at the top end closed by being pressed against the upper lip, so that the first side hole is under the left nostril. The right nostril is closed with the right thumb, and the top hole practically becomes the embouchure of a temporarily transverse flute. The sound produced is, however, feeble, and I do not think that the *koauau* was generally used in this way as a nose-flute—in most instances the perforation of the holes would not allow of it. Old illustrations are unsatisfactory. These usually represent the nose-flute as much longer than the *koauau*, and the blowing appears to be directly into the tube, not across, as in the *koauau*.*

In the bone flutes the three holes are usually the same distance apart. Here again three is the usual number of holes, one near the top being used for suspension ; and whilst this hole is usually at the side, out of the line of the three sound-holes, it is at times in the same line. There is a beautiful little example of a bone flute from the John White collection in the Otago University Museum (Plate 83, fig. 4). It is only 115 mm. in length, and the original three holes are respectively 31 mm., 48 mm., and 67 mm. from

* See illustration in Jules et Édouard Verreaux, *L'Oceanie en estampes*, p. 314 ; Paris, 1832. See also various references in Hamilton, p. 386, footnote.

the top end. Three additional holes have been pierced, at 34 mm., 58 mm., and 76 mm. from the top. The later-pierced holes can easily be distinguished from the others, being smaller and out of line; but it is impossible, except for a child with the slenderest fingers, to stop these holes, so close together are they. I have repeatedly endeavoured to sound this flute, but it and all those of bone, with the three equidistant holes, have completely baffled my attempts to sound them: I can get no more than a whistling suggestion of what the notes may be. There is, however, as much diversity in the proportions of the bone flutes as in the *koauau*.

No help may be had from the *putorino*, or *torino*, or *pu*. This is also a flute-like instrument, much longer and larger than the *koauau* (Plate 84, figs. 1–5). Its bore is irregular, swelling in the centre, and contracting at either end, the lower end being much smaller than the upper. In order to make the cavity in this instrument, the outside was first shaped, when the wood was split into equal halves, and the two halves hollowed out canoe-fashion. The two pieces were then fitted together again and lashed with flax cord or finely divided vines. It is played by blowing bugle-fashion into the larger end, the sound being modified by moving the fingers or the hand over the single large central hole or over the very small end hole. The central hole is large, and is usually shaped like an elongated figure of eight, the corners at the waist approaching but not meeting. This instrument, like the *koauau*, is often highly ornamented with carving, the central hole being made in the representation of a grotesque open mouth—a humorous touch. The humour is grim when it is seen that the contraction of the mouth at the middle resembles the contraction seen in dried heads. If the head were that of an enemy, the lips were allowed to open as they shrunk, leaving the teeth exposed: if it were the head of a friend or relative, the lips were usually sewn together and kept closed. At times the only sewing was at the middle, when on drying there was an opening on either side of the central constriction. The opening of the *putorino* often resembles such a mouth, one of which is perfectly illustrated at p. 145 of Robley, *Moko; or Maori Tattooing*.

No definitely graduated series of notes can be produced on this instrument, which is therefore of no value for the purpose of detecting any scale that may have been used. Iehu Nukunuku said that it might be played with the *koauau*, but it only made a deep booming or murmuring sound, which trembled as the fingers were moved, not lifted, over the opening; the sound was likened to the bubbling of water into a calabash held under the surface, as is seen in the saying, "*Me te wai e utuutu ana.*" The sound was also varied by the finger closing the hole at the small end. (*See* Hamilton, figs. 1, 4, pl. 58, p. 419, and fig. 1, pl. 59, p. 421.)

A third flute-like instrument is the *nguru*, made of wood or stone (Plate 85, figs. 5, 7). It was used rather as a signalling than as a musical instrument, and its sound was said by Cook, as noted above, to be no more musical than that of a pea-whistle. He likens its shape to a child's ninepin; Banks likens it to a tobacco-pipe. Colenso (1881, pp. 80–81) calls it a whistle: "Their whistles were very large; that is, thick, obtuse, peculiarly shaped, and something like a short thick tongue, some being a little curved. They were made of hard wood, scraped, polished, and profusely carved, and inlaid with mother-of-pearl; these also were worn by the chiefs, hung to their necks. Parkinson (Sir Joseph Banks' draughtsman) has given a drawing of one in plate 26 of his interesting 'Journal,' figure 24;—in describing it he says: 'A whistle made of wood having the outside

curiously carved; besides the mouth-hole they have several for the fingers to play upon. These, which are worn about the neck, are 3½ inches in length and yield a shrill sound.' I suspect that these, like their trumpets, were not used for obtaining any proper tune, but only for the purpose of making a loud call,—as from a chief to his followers." (*See* Hamilton, fig. 2, pl. 58, p. 419; and p. 225.)

Of their trumpet, *putara*, Forster says (vol. 1, p. 227): "They also brought some musical instruments, among which was a trumpet, or tube, of wood, about four feet long, and pretty straight; its small mouth was not above two inches, and the other not above five inches in diameter; it made a very uncouth kind of braying, for they always sounded the same note, though a performer on the French horn might perhaps be able to bring some better music out of it. Another trumpet was made of a large whelk (*Murex tritonis*) mounted with wood curiously carved, and pierced at the point where the mouth was applied; a hideous bellowing was all the sound that could be produced out of this instrument." (*See* Hamilton, pl. 30, fig. 1, p. 245.)

The shell trumpet, *pumoana* (Plate 84, fig. 6), Colenso (1881, pp. 78–79) says was made from the shell of *Triton australis*, its apex cut off, and a mouthpiece of wood lashed on. A method of increasing, or modifying, or altering the sound in some way was adapted by the insertion of a thin piece of hard wood "of a broadly elliptical form, and measuring 5 × 3 inches, most dexterously fitted in to fill up a hole in the upper part of the body or large whorl of the shell," only one sort of wood, *kaiwhiria* (*Hedycarya dentata*) being used for the purpose.

Though not an indigenous musical instrument, the jew's-harp was introduced very early, and quickly became a favourite. It had its prototype in the *roria*, an instrument which simply consisted of a thin strip of the outer casing of the supplejack-vine, about 3 in. or 4 in. long and ¼ in. wide. It was held between the teeth, and sprung with the finger, the sound of the vibrating strip being modified by varying the opening of the lips. The name *roria* was later applied to the jew's-harp itself. Of this latter instrument Colenso writes (1881, p. 82): "It is well known that at an early date, say, forty years ago, the Maoris showed a great desire to obtain jew's-harps: this was common. But to see them . . . critically examine and try a whole score, or more, of those little instruments, before one was found that was 'soft' enough (or suitably melodious) in its twang to please their ear! I have known them to leave the store where jew's-harps were sold without purchasing one after trying many, though sadly in want of one at the time, rather than bring away a 'hard' or unsuitable one. They also spent much time in endeavouring to alter its tone, by trying all manner of schemes and plans with its tongue. Again, in later years, I have known them to improve on the sound of the jew's-harp (for their ear), by fixing a lump of sealing-wax, or *kauri*-resin, on the projecting end of the tongue of the instrument, for the purpose of playing the same *within their mouth and with their tongue*, instead of with their finger! This certainly rendered the sounds much softer than when played in the usual way. Young men would sometimes be thus occupied for one or two hours, evidently delighting themselves with the dulcet sounds."

To those who know the jew's-harp only as a toy these facts may again suggest a poorly developed musical taste in the Maori. The instrument is capable of producing tunes, and really beautiful effects, and there is no doubt that the Maori perceived at least some of these. The writer learned

from Mr. H. Stowell, however, that there was quite another reason for the Maori partiality to the jew's-harp. Any one who has experimented with it knows how, by altering the shape of the mouth-cavity and the position of the lips, it is possible to produce most varied vocalizations; and the Maori discovered that he was able actually to speak through the instrument—that is, the vocalizations could be made to approximate the sounds of speech. Definite songs would be composed for the instrument; and Mr. H. Stowell has told me that, after the song had been played two or three times over, the listeners were able to repeat the words intended by the player. This might not be so very difficult in Maori, where vowel sounds preponderate so largely. It was not, then, the *music* of the jew's-harp that appealed to the Maori, but its capability of speech. I learned from Mrs. Ngata, wife of the Hon. A. T. Ngata, M.P., of Waiomatatini, that when she was a girl lovers might be seen sitting side by side, heads close together, each with a jew's-harp, known as *kukau*, speaking to each other very softly on the instruments, one hand covering the instrument and the mouth.

In bird-song, too, it was the song that approached nearest to vocalization that appealed most to the Maori. This is one reason why the tui was such a favourite; his short phrases of song were so often short phrases of speech; he was continually saying something, and to the ear of the Maori that something was often of a humorous nature. The writer has repeatedly observed this fact, and in many of the notes of birds, tui and other, recorded by him, vocalizations are given, and these often resemble a short phrase of speech, which very little imagination renders quite definite. The writer has heard a phrase that immediately suggested a short sentence of six Danish words; and Maori words are much more easily discerned in the vocalizations. So far as the writer has observed, the Maori now pays little attention to bird-song that is not capable of vocalization. He has more than once been near bush with Maori friends, and hearing a miromiro, or riroriro, or piwakawaka, or other small bird, he has asked, "What bird was that?" "Where?" the reply has been, whilst the eyes ranged round; they had not heard the notes—at any rate, were not conscious of having heard them. Or, on drawing their attention to the notes whilst still sounding, they would say, "Oh, I suppose it is a so-and-so," as often as not naming quite another bird than the one singing. In fact, their appreciation of melody, as melody, was undeveloped, though it is evident it was near emergence. This is made clear by the many suggestions of melody, not merely of speech-tune, in their songs—and still more by their unhesitating adoption and enjoyment of European tunes. Their sense of harmony, too, must have been near emergence, and the writer has had experience of their quickness in harmonizing a tune. He wrote a song with a chorus in $\frac{3}{4}$ time, and one evening six or eight young people were in the room and wished to learn the song, singing it over with the writer; and when it came to the chorus they harmonized it while they learned it; one youth was especially apt at the harmonizing.

The song of the cicada, too, was liked, but principally because it sounded in midsummer, the time of warmth and plenty. It has little melody, but fine rhythm. A Maori poet at one time was inspired by the rhythm and characteristic vocalization, and on his writing a *haka* song based on these it immediately became a great favourite. It appears later on in this paper.

As regards the sound of the *putara*, the long wooden trumpet, it was more appreciated because its vocalization permitted of insulting words being blown at the enemy. (Colenso, p. 80, note (1).)

The songs of the Maori were exceedingly varied in character. On going over the extensive catalogue of names of different kinds of songs it is seen they were used on every possible occasion—in games and in religious ceremonies, in sickness and in health, in sorrow and in happiness. The names are not applied in any definite manner; there are several general names, but many songs included under one may equally well be included under another. The term *karakia* covers an enormous field; it includes all ritual chants, from the most sacred to the most ordinary, also charms or spells of all kinds. A *karakia* was usually intoned in monotone, much as our own church ritual may be intoned. There were all manner of sub-divisions of the class *karakia*—such as *kawa*, including ritual chants in connection with new houses or canoes, birth of a child, &c.; *kaha*, a general term for charms used when fishing, bird-snaring, &c.; *matapuru*, a class including charms to ward off witchcraft.

The term *waiata* refers more to songs with some modulation, some approach to melody, and includes *waiata aroha* (love songs), *waiata tangi* (laments), *waiata wawata* (songs of longing).

The term *tau* in part covers the same ground as *waiata*, but it in part covers the same ground as *karakia* also, since it includes songs with modulation as well as intoned chants; the latter, however, have less to do with ritual. It is noticeable, during the taking of records on the dictaphone, that the singer, if in doubt as to what to call the song about to be sung, very often said "*He tau*" ("a *tau*").

The term *haka* includes songs with action, and these may be either intoned or modulated.

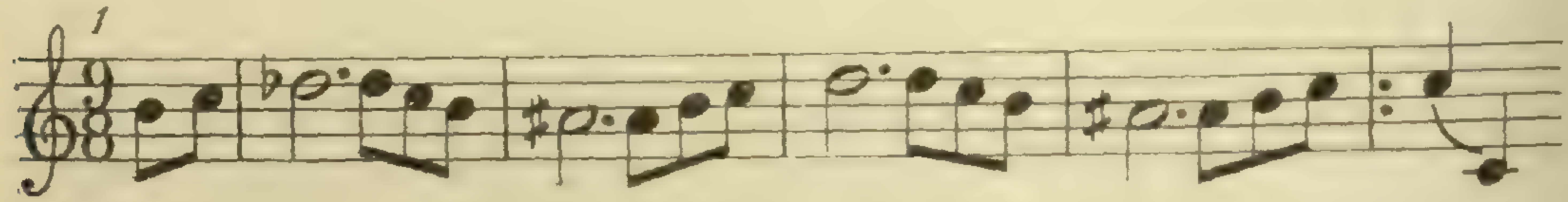
These are a few of the more definite classes, but songs whose subject should apparently include them in one or other of these may have quite another name: thus, *pihe* and *kaha* are both dirges or laments, or *waiata tangi*; *hari* is a song with dance; *peruperu* a war-song accompanied by action and dance.

Whilst as a rule the musical accompaniment to the song was quite subordinate, there was yet a class called *rangi* (*rangi* meaning an air or tune): there were *rangi putorino*, songs sung to the *putorino*; *rangi koauau*, songs sung to the *koauau*; *rangi pakuru*, songs sung whilst the *pakuru*, a slender rod held between the teeth, was struck with a smaller rod; *ngari porotiti*, songs sung while twirling the *porotiti* or *kororohu*, the whizgig; *ngari titi-touretua*, songs sung for time-giving whilst playing the game *titi-touretua*, where sticks are thrown from player to player. In the last two the word *rangi* has been transposed to *ngari*. When sung to an instrument, voice and instrument were always in unison, so that a *rangi koauau* would be a song whose melody would be accompanied by a *koauau*.

At Rotorua, during the time previous to the arrival of His Royal Highness the Prince of Wales, in April, 1920, the songs most commonly heard were *tau*, of the sub-class *tau marae*, or songs sung in the common meeting-ground, the *marae*. These were heard every time a new party of Maori arrived at the encampment, and every party had its own particular *tau*, composed for the occasion.

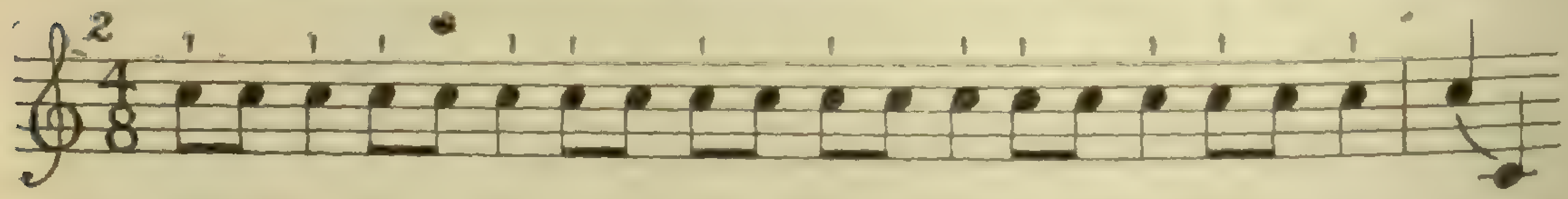
On a party arriving, the procedure was usually the same, though the songs differed. The local people sat on the *marae*, the visitors advancing slowly. From the ranks of the local people an armed man ran out alone towards the visitors, grimacing and brandishing his *taiaha* in challenge. The challenge would be accepted by one of the visitors, who, similarly

armed, would leave the ranks of his party; these two, after a mock encounter, returned to their respective parties, the visitors slowly approaching amid welcoming cries. They paused when a space of about 30 ft. separated the two bodies of people, when the keening took place. Suddenly the keening ceased and the visitors began their chant. In the particular instance noted the Wairoa were the visitors, and their chant was as follows:—



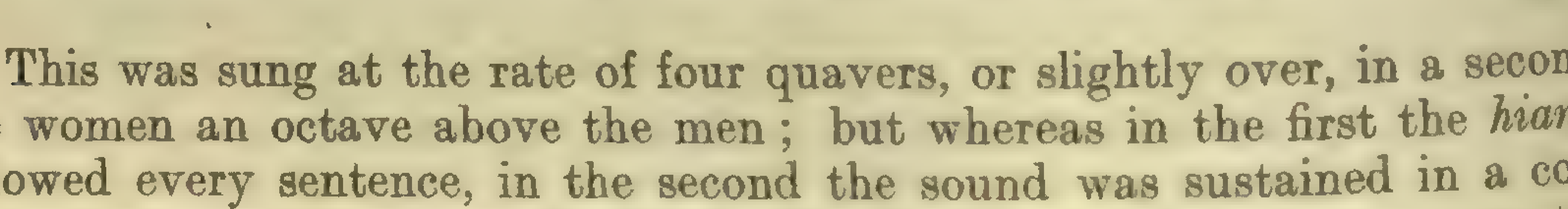
This was a wailing chant, rising and falling, sung very softly, repeated as the varying length of the sentences required, each sentence being closed by the *hiangi*, or slurred drop through an interval of an octave or less. This chant bears some resemblance to the first one recorded by Forster.

The local people immediately followed with a rhythmical monotone:—



This was sung at the rate of four quavers, or slightly over, in a second, the women an octave above the men; but whereas in the first the *hiangi* followed every sentence, in the second the sound was sustained in a continuous stream from start to finish, the *hiangi* coming only once, at the close. One could hear where occasionally a voice ceased for a few seconds, joining the body of sound after the singer had taken breath. A most strange effect is produced on the hearer by this unbroken rhythmical monotone, and the effect of *karakia*, which are intoned in a similar way, can easily be understood. There was a trace of accent on every alternate quaver, or crotchet when this took the place of two quavers, as though the chant were in 2 rather than in 4 time. A chant similar in all respects to this was sung by the Tuhoe people at Gisborne the year before, all standing grouped together in the marquee allotted to them.

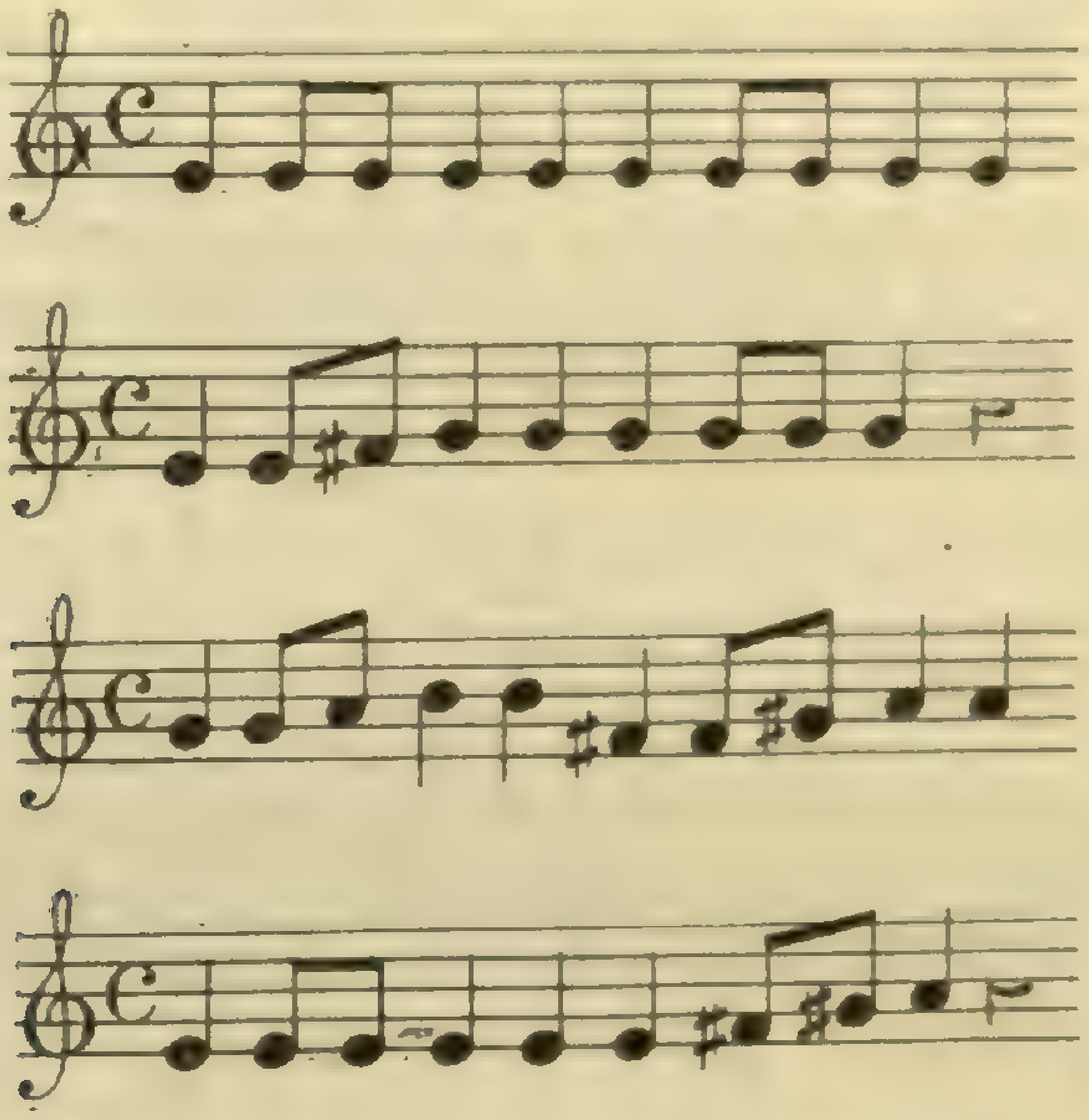
The usual speeches by both parties followed the chant 2, and the local people then sang a third song, with the following rhythm:—



Whilst the rhythm appears the same, the effect is quite different, there being in this no trace of accent. The first part, again, varied in length according to the length of the sentence; towards the close of the sentence the pitch rose a semitone or less, dropping again to the opening pitch immediately before the closing *hiangi*.

It will be noted that the rhythms of 2 and 3 correspond exactly with the theoretical rhythm of the Greek anapest and dactyl respectively, the former consisting of two short syllables followed by a long, the latter of a long followed by two shorts—a long being always, theoretically, twice the length of a short. With very little modification the Maori chant 3 would correspond with the hexameter.

The second movement in Beethoven's Seventh Symphony is based on a rhythm almost identical with the above :—



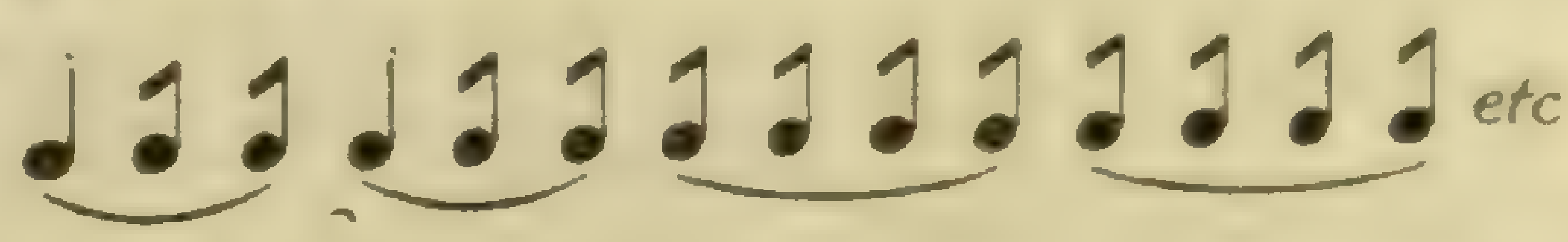
The great formal difference is that the Maori chant is rhythmical, but Beethoven's rhythm is metrical in addition.

In another chant the rhythm of the trochee was noted :—

4

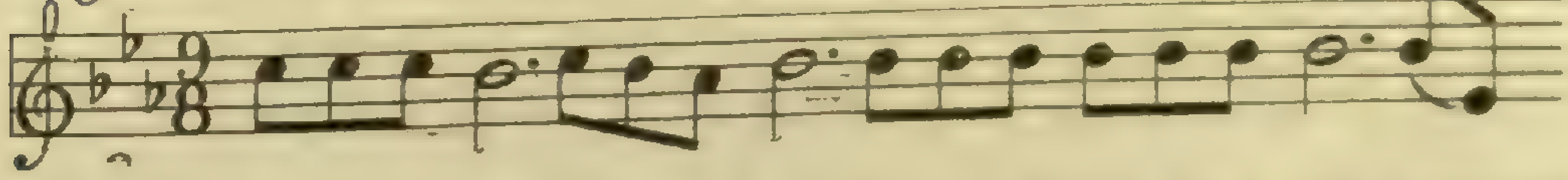
Here the long-short was often resolved into the equivalent three shorts, the tribrach, and the rhythm of the chant consisted of various combinations of these two, trochee and tribrach.

Another chant in dactylic rhythm differed from 3 above in the long-short-short being often resolved into the equivalent four shorts :—

5 

One morning at Rotorua a woman was heard uttering the following :—

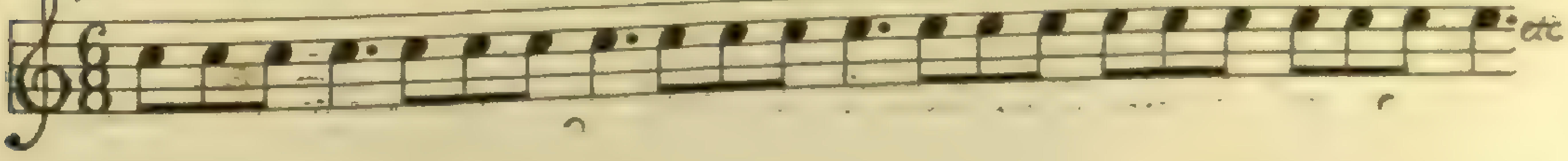
6



It was very early, about 4 o'clock, but this chant rang out apparently without regard to the sleepers round about. It sounded very strange, rising from an otherwise quiet camp. The rhythm is the same as 1, but the wailing quality was absent.

A similar rhythm was heard in one of the songs of welcome :—

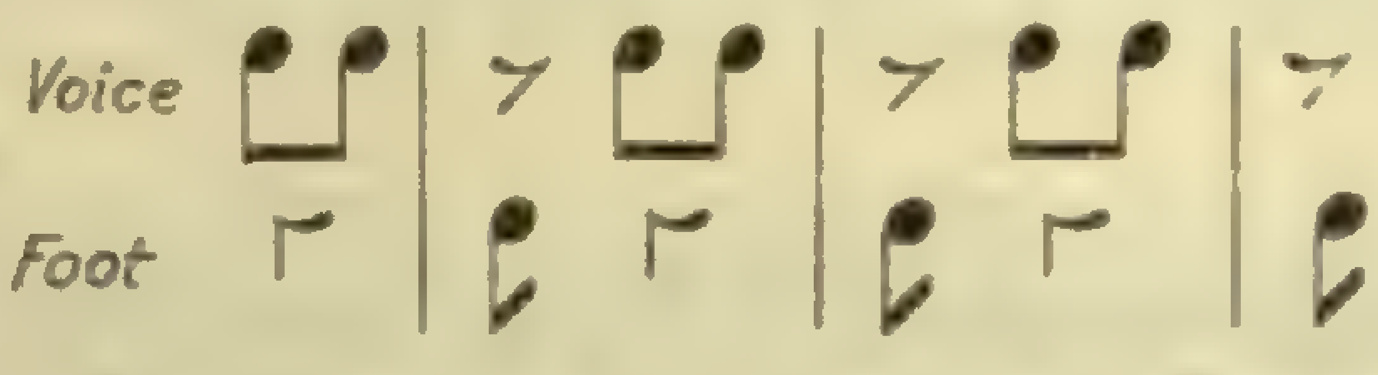
7



In these *tau* is observed the perfect time kept by the singers, the chant often sounding as though uttered by one composite voice. When action enters the songs the same unanimity is observed. Captain Cook noted the striking of a hundred paddles against the sides of a canoe so as to produce but a single sound; and in the performance of the *haka*, especially when men perform alone or women perform alone, the various sounds, of voice, hands, or feet give the effect of the augmented voice and action of a single person.

The following is the outline of a simple *haka*:—

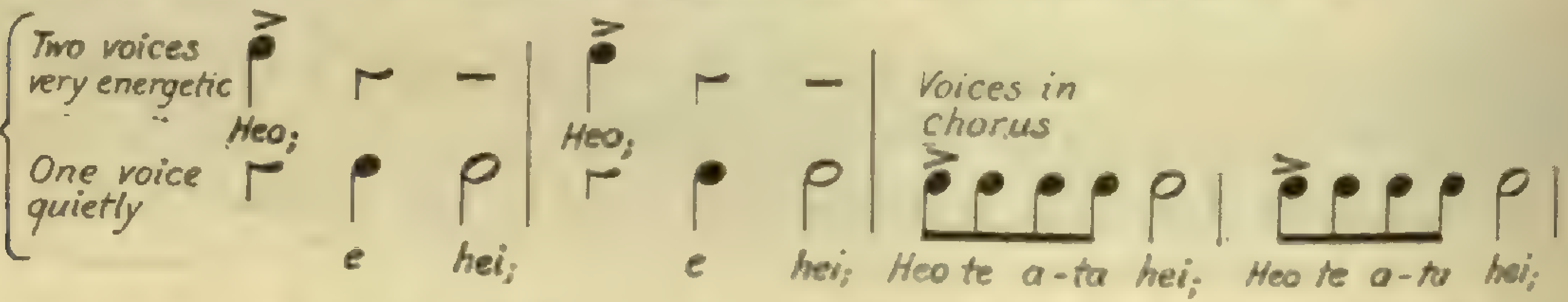
8



Though this was opened by the voice, the beat was on the stamp of the foot, when the voice was silent, the cessation of the voice adding emphasis to the stamp. This is the scheme for a *ngeri*, one of the many kinds of war-song.

On a similar scheme, producing an altogether different effect, is the following, heard at Koriniti, Wanganui River, in March, 1921:—

9



Some young men were practising, two voices singing the *Heo* with very great vigour, one voice following very quietly with *e hei*. This was repeated, and then all three joined, singing the rest together, quickly and vigorously, in the rhythm of the second line.

In many of their songs the time was given by men with *taiaha* or other form of baton in their hand. These men were called *kai tuki*, or *hau tu*. If in a canoe, one or more would stand on the thwarts, giving time with voice and gesture to the paddlers, who might also be singing; they would even run backwards and forwards along the thwarts whilst thus directing the crew.

The familiar *poi* song and dance is one of many posture-dances popular with the Maori; too often, however, a foreign melody takes the place of the old Maori melody or the old monotone. The following is an extremely popular *haka*, based on the shrill summer-singing of the tarakihi (cicada). This is the song that came to the Maori poet, wandering on a summer afternoon in search of inspiration. Approaching a grove of mahoe, in a sequestered, romantic nook, he was suddenly aware of the delirious joy-song of the assembled tarakihi throbbing in the air. At once he composed an introductory stanza followed by a chorus of tarakihi:—

E whakarongo ai au,
Ki te tangi mai,
A te manu nei,
A te tarakihi
I te weheruatanga o te po:

Ta ra ra-ta, ki-ta, ki-ta,
Ta ra ra-ta, ki-ta, ki-ta,
Wiri opapa, toene, toene,
Wiri opapa, toene, toene,
Hope whai a ke
Turi wha tia,
Ei, ei, ha!

Oh, my fancy listening
To the song of songs
Of this singing bird,
Of the tarakihi,
In my dreams in the midst of the night.

Ta ra ra-ta, ki-ta, ki-ta,
Ta ra ra-ta, ki-ta, ki-ta.

O quivering sides, sound the refrain,
O quivering sides, sound the refrain,
And with waist supple,
And bended knees,
Ei, ei, ha!

This song, obtained by the writer through the kindness of Mr. Henry Stowell (Hare Hongi), at once seized the popular imagination, and it was soon converted into a *haka*, or posture-song and dance, with the following introduction :—

E pakia kia rite,
E ko te rite, kia rite,
E takahia kia ngawari,
E torona kei waho hoki mai.

O slap-slap in unison,
O evenly, evenly,
O stamp the feet regularly,
O stretch well forth and draw back again.

On the word *pakia*, the thighs are slapped with the open hands, and again on the word *kia* :—

E *pà*-ki-a *kìa* ri-te,

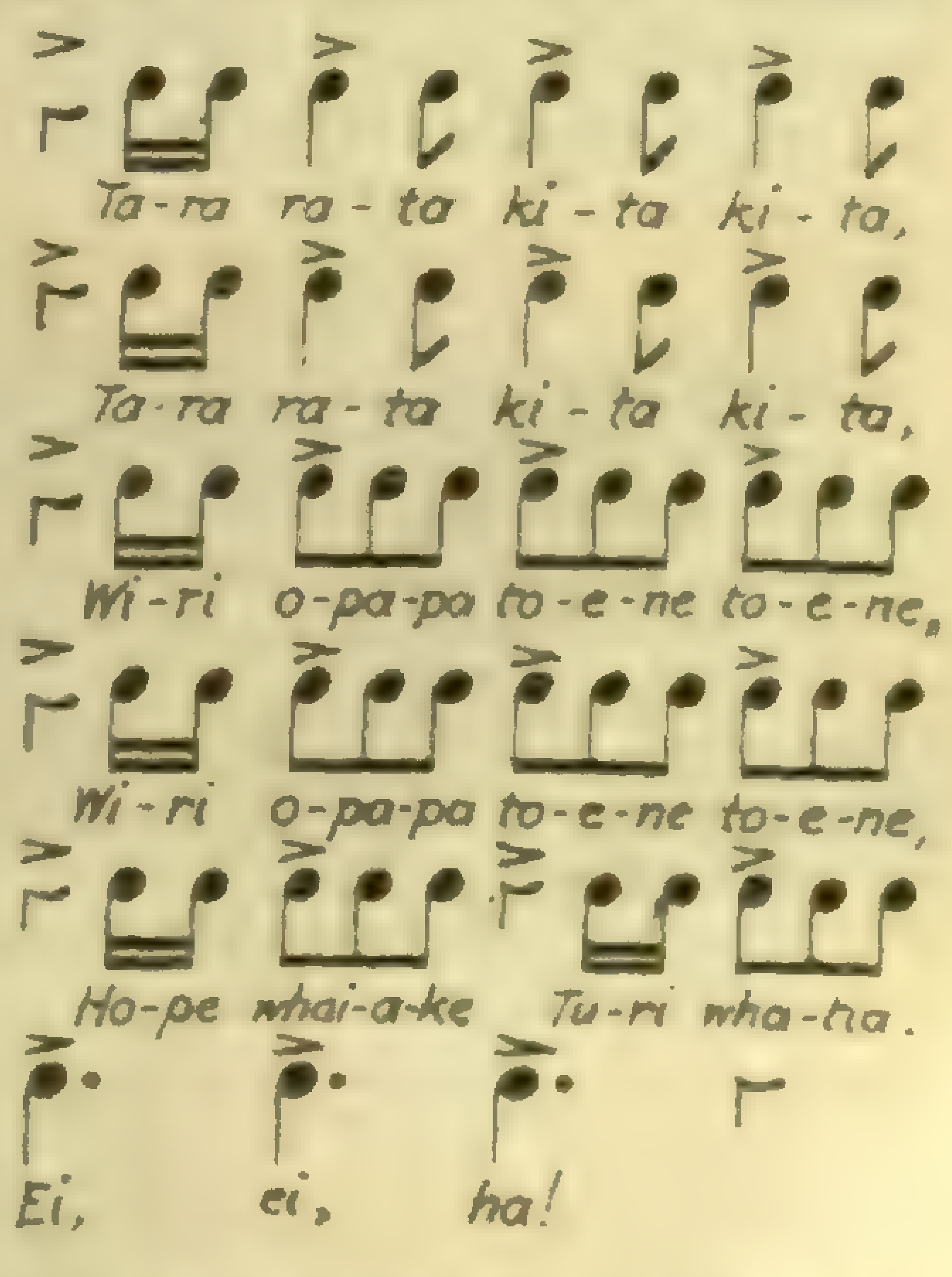
so keeping time whilst the leader gives the next line, where the thigh-slaps are on the words *ko* and *kia* :—

E *kō* te ri-te, *kia* ri te,

and are continued rhythmically through the next line. Following the thigh-slap, on the word *ngawari*, the right feet are brought down with a stamp in unison with the corresponding thigh-slap. The stamp and slap together then continue through the fourth line. Following the stamp and slap, on the word *hoki*, all arms are stretched well forward, and brought back until the fingers of the inturned hands just tip the shoulders, exactly in time with the foot-beats. These actions are continued through the delivery of the opening stanza :—

E whakarongo ai au.

On the word *Ta*, the first of the chorus of the cicada, the hands are slapped together, probably in imitation of the clicking accompaniment to the insect's chirring song, and so on according to arrangement. The rhythm of the chorus is most distinctive.



The syncopation carried through all but the last line, and doubled in the last but one, is characteristic of the Maori rhythms.

These rhythms are of very great variety, and when a large body of people takes part they are extremely effective, the many strange actions and gestures adding a picturesque wildness. It is noticeable that metre and melody do not go together; the more a song inclines to metrical rhythm, as in the dances, or songs with actions, the more subordinate does the melody become; and those most distinctively melodious are the laments and love-songs, where a certain rhythm may be present, but no metre.

As varied are the songs in which rhythm enters very little, if at all; songs usually sung by one person only, or by one person and a chorus. Watch-songs, love-songs, laments, lullabies, taunting-songs—all have their distinctive character. In listening to one of these, more especially the love-songs or laments, one gathers the impression that the singer dwells chiefly on the best note of his register, his voice rising and falling with his emotion above or below the note, but always returning to it, and on it singing the greater part of the song. The less expert the singer the more he dwells on the one note. The sentences of the songs are of varying length, and each sentence is sung to the same theme, the "wandering" notes, either above or below the chief note, not always agreeing exactly in pitch or combination. Yet there is, apparently, a recognized theme for the phrase, a theme that may be slightly varied but never left altogether. The *hiangi* at the close is not an indication that the breath is exhausted—it is the end of a sentence only; and I have often heard a singer with long breath take the *hiangi* and go on directly without pause to the following sentence. Lullabies are usually on one note, more in the nature of a chant; and here the singer goes on while breath lasts, and the break for taking breath may be in the middle of a word. I have heard the word *aroha* thus broken: breath would be taken after *aro-* had been sung, the new phrase beginning with *ha*, the second part of the word. The Maori does not appear to have a word-sense as we have it; an expression appeals to him more as an expression, not so much as individual words, so that even in dictating the words of a song he will give groups of syllables that may contain several words and part of a word. All syllables end with a vowel, and there appears to be a tendency to make them begin with one also; so that *aua none* and *aua rekareka* were given by one dictator as *au anone* and *au arekareka*. This may be a common natural characteristic, for a similar word-division appears in the odes of Horace, and in the quatrain headings to the cantos of Spenser's "Faerie Queen." Analysis of some of the complicated melodies may be undertaken in a later paper.

I wish to thank the Venerable Archdeacon H. W. Williams, Mr. H. D. Skinner (Curator of the Otago University Museum), and the Director of the Dominion Museum for giving me the opportunity of examining many flutes and other instruments; also Mr. Elsdon Best, Mr. Henry Stowell, and Dr. Peter Buck (Te Rangi Hiroa) for much information that I could never obtain personally, and Mr. J. McDonald, of the Dominion Museum, for photographs taken and other assistance afforded.

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ART. 47.—*New Zealand and other Bird-song: Further Notes.*

By JOHANNES C. ANDERSEN.

[*Read before the Wellington Philosophical Society, 19th July, 1921; received by Editor, 20th July, 1921; issued separately, 18th June, 1923.*]

THE notes following have been recorded since publication of the last series, in 1918. As before, for convenience of reference, the variations in the notes of each species of bird have been numbered consecutively from (1) onwards, the earlier numbers appearing in *Trans. N.Z. Inst.*, vol. 41, p. 422; vol. 43, p. 656; vol. 45, p. 387; vol. 47, p. 593; vol. 49, p. 519; vol. 50, p. 282.

GREY WARBLER *(Pseudogerygone igata)*.

The warbler sings many rhythmical phrases, a considerable number of which have been recorded. No. (40) is a characteristic one, in slow, swinging 2 time, heard in Wellington. It has also been noted that every different locality appears to have a song that is not heard elsewhere, in addition to the songs common to all localities. No. (41), a phrase in

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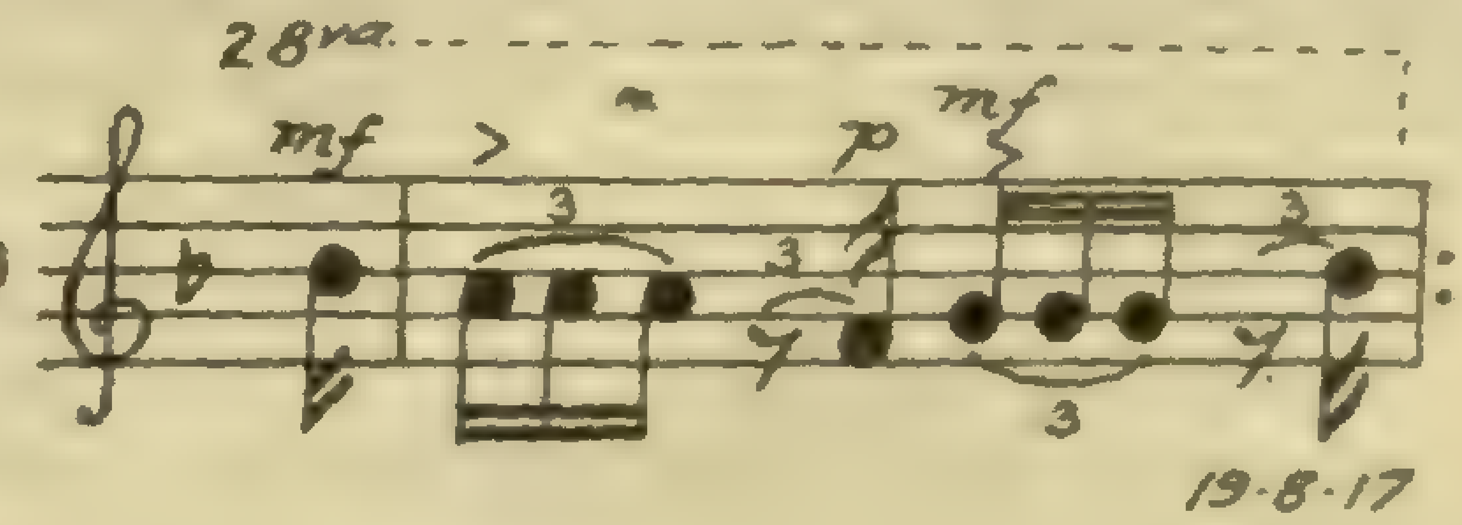

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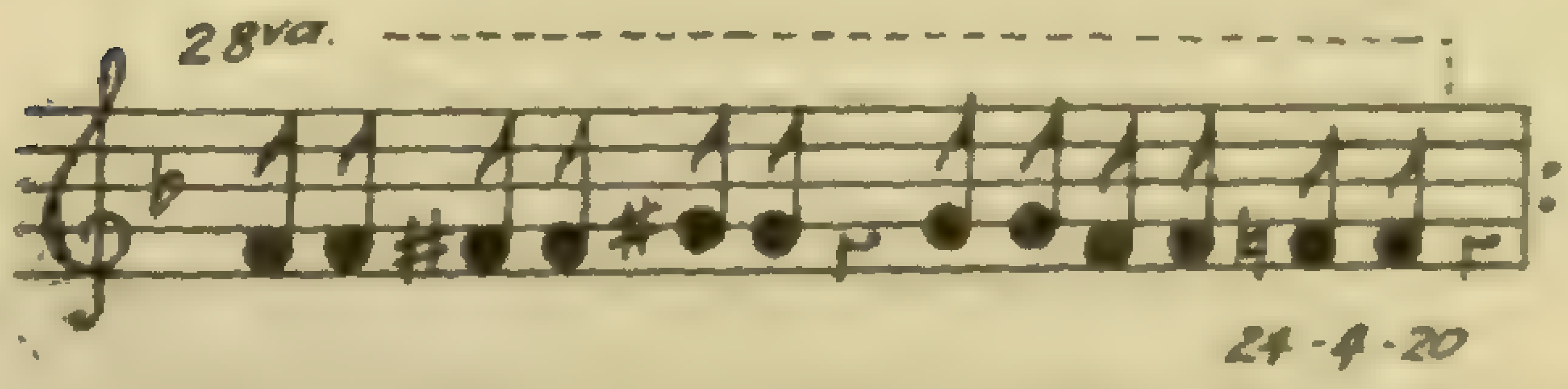

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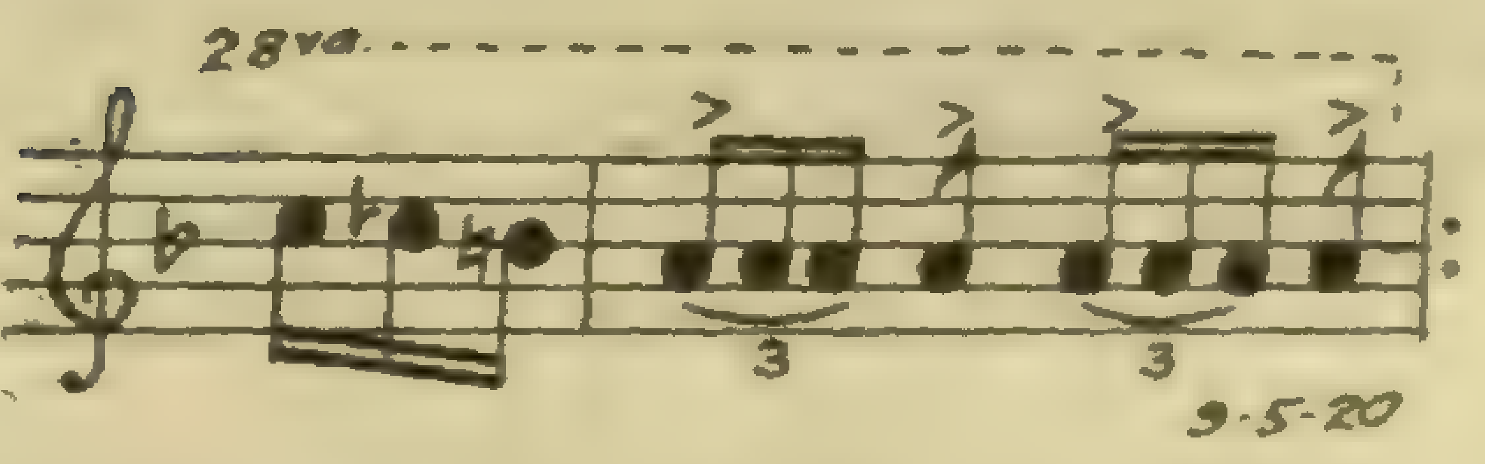

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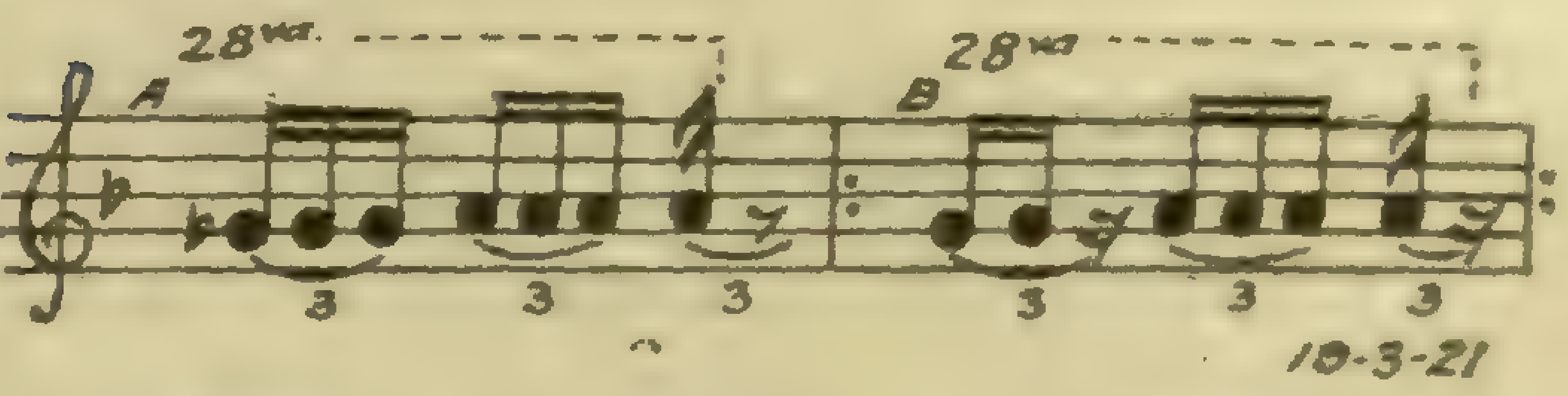

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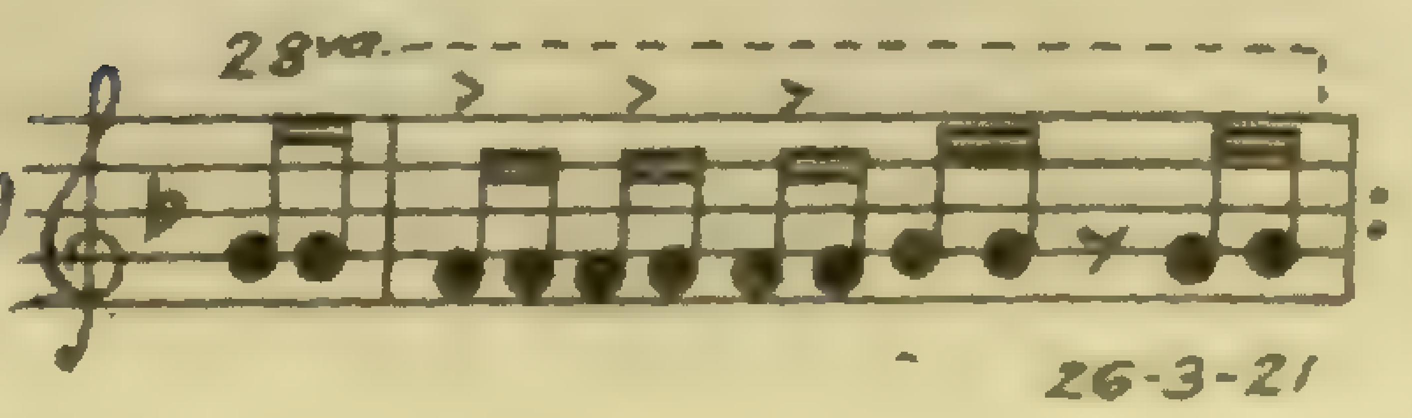

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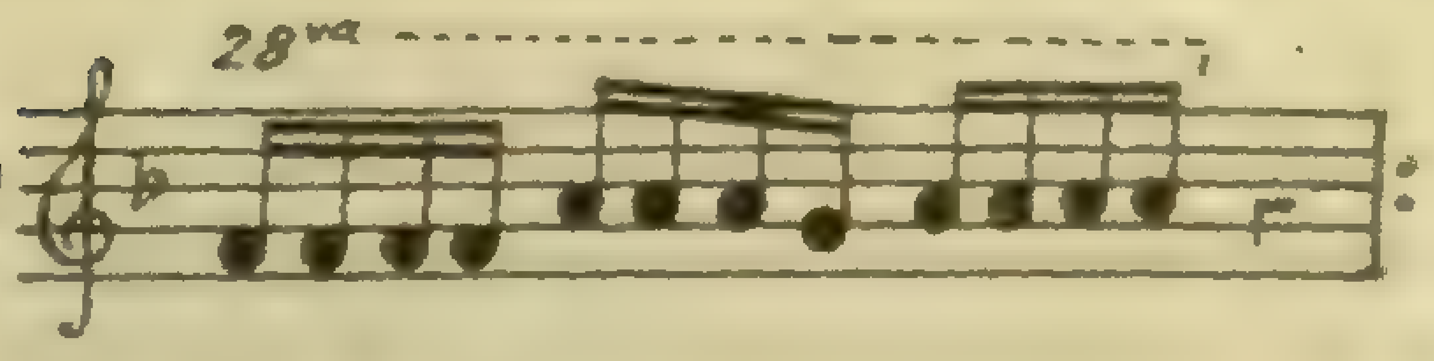
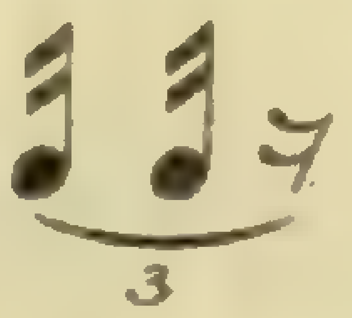


4 time, was heard at Rotorua, as also was (42), whose triplets were introduced by a triplet falling in quarter-tones. The quaver was at times

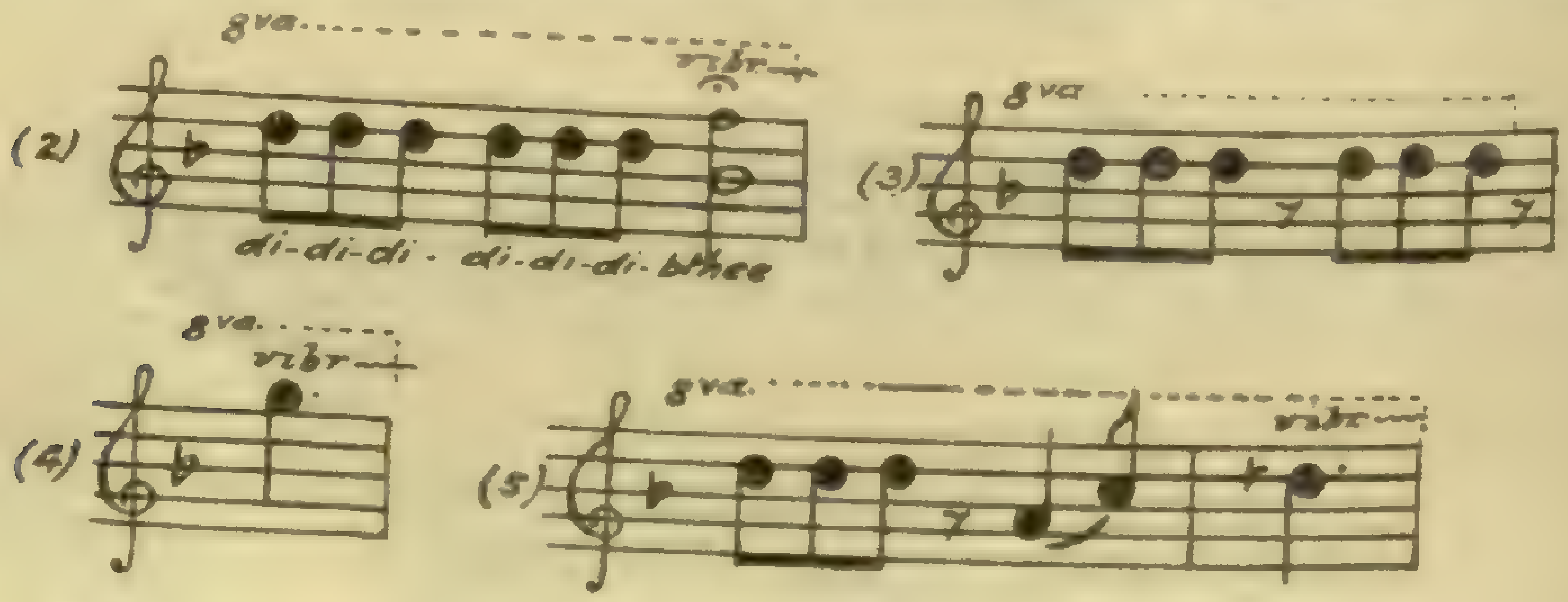


Local song was also heard at Hiruharama, on the Wanganui River, as in (43)–(45).

The local nature of many of the songs suggests that the birds remain more or less in one locality of indefinite but comparatively restricted extent. On a review of the songs recorded it seems possible that there may be at least two species of warbler. In all localities with which I am most familiar the warbler has two distinct types of song—one bright and cheery, the other plaintive; the latter being the one more often sung, and subject to the greater amount of variation. The two types as heard around Wellington are best represented by (38A)–(38C), and (29), (29B) (*Trans. N.Z. Inst.*, vol. 49, pp. 527, 526, 1917). It is the latter type, in one or more of its many variations, that I hear in parts of New Zealand visited by me only occasionally. In the Stony Bay bush, Banks Peninsula, however, the two types of song are as (13)–(16) (*Trans. N.Z. Inst.*, vol. 45, p. 394, 1913) and (3) (*Trans. N.Z. Inst.*, vol. 41, p. 425, 1909). The second of these is a long, indeterminate, rambling melody, never broken into definite phrases as in other localities, and I have heard it only on the west coast of the South Island besides at Stony Bay; in the latter place it is the invariable song of the second type. Fragments of the indeterminate song may be heard elsewhere, but only fragments; there are definite phrases in addition: in Stony Bay bush the definite phrases are absent. This leads me to suppose that there may be a variety of the warbler on Banks Peninsula, or at least in the South Island.

Pipit (*Anthus novae-zealandiae*).

Whilst camped at the head of the Godley River Valley in December, 1920, and January, 1921, the pipit was almost the only bird either seen or heard. The camp was pitched at the foot of the last vegetation-covered spur of the Sibbald Range, near the terminal face of the Godley Glacier. From the alpine garden of hillside above I heard, as I thought,



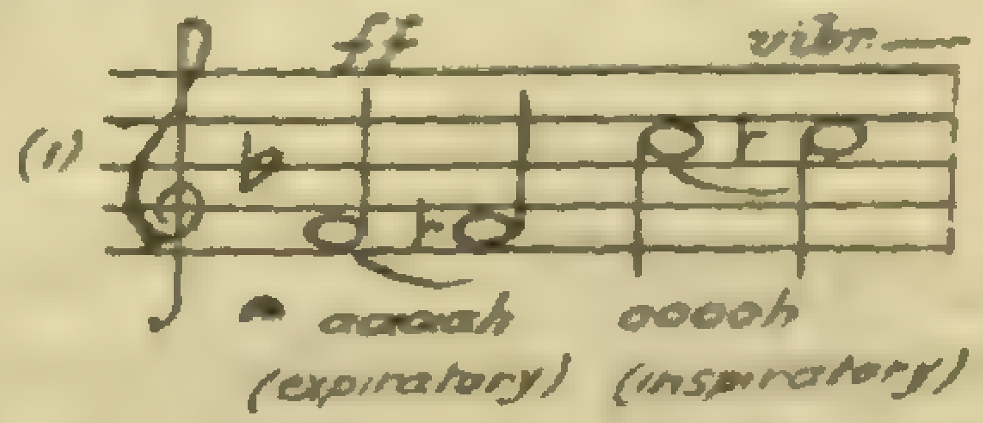
pipits, yellowhammers, and goldfinches. On climbing the spur to catch a sight of the birds, however, I found pipits only. The phrase I had taken for that of a yellowhammer was (2). It resembles that of the yellowhammer very closely not only in length and interval, but also in vocalization. The phrase of the yellowhammer has been likened to the

words *little bit of bread and no cheecese.* I could not hear these sounds in the pipit's notes; the vocalization was *di-di-di-di-di-di-bthee*, where some of the vowels agree with the yellowhammer's, but not all. I many times saw the birds that sang all the notes recorded, but never once saw a yellowhammer there, though these were plentiful enough in the lower country. The notes were sung about four a second, and there was a burr or throb on the final note, vocalized *bthee*, in which, too, I fancied I detected an overtone of a fifth, or twelfth.

The common call was as in (3), sung about six notes to the second, the reply being as in (4). If there happened to be no reply to the call (3) after it had been made two or three times, an addition was made, as in (5). This was a plaintive slur, like the slur of a goldfinch or the *sweet* of a canary. It was hearing this slur, before I saw the birds, that led me to think they were goldfinches on the hillside. The place of the slur was sometimes taken by a vibrato note, half-flattened. The slur was often sounded alone.

BLUE PENGUIN *(Eudyptula minor)*.

I had good opportunity for hearing this extraordinary song, if song it may be called, on Kapiti. During stormy weather blue penguins resort to holes under the floor of the *whare* where we slept; and during one night two birds, for many minutes at a time, kept up this dolorous lamentation. The first notes, long-drawn, and vocalized *aaah*, seemed expiratory, and were like the imploring cry of a child, crying piteously;

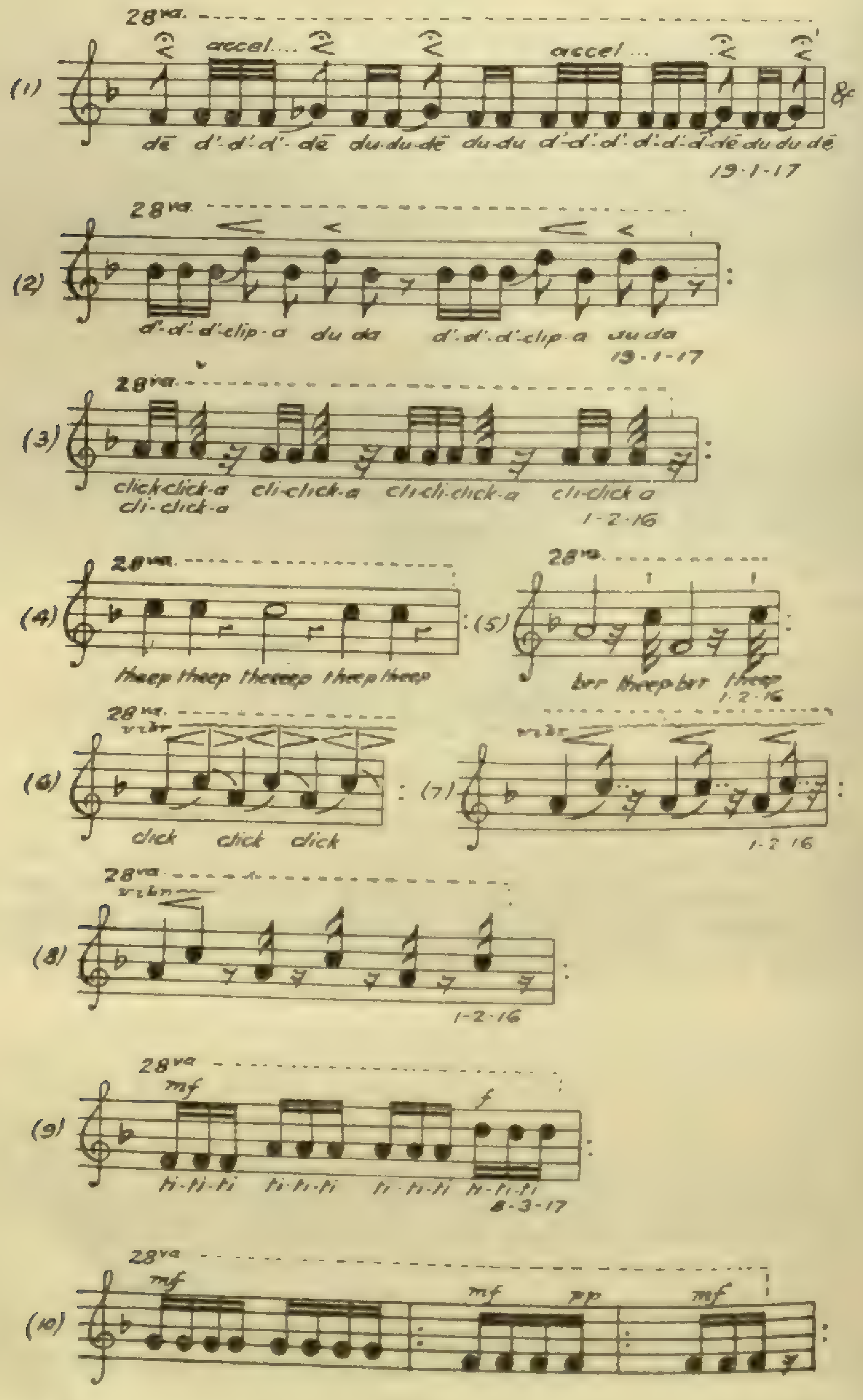


the higher notes following, also long-drawn, and vocalized *ooooh*, seemed inspiratory, and were like a choking cry, with vibration at the close of the slur. Presumably the birds enjoyed the duet since it was so long-continued, but it seemed rather the despairing lament of two lovers about to be parted for ever, than the crooning of two happily united.

CICADA; TATARAKIHI, OR TARAKIHI *(Cicada cingulata)*.

Whilst this is not a bird, it has a song, and the song was liked by the Maori above all others; indeed, he called the cicada "the bird of Rehua." Rehua was the lord of kindness, and the reason the Maori held the insect in such estimation was that its cheerful song sounded in the summer when the days were warm and long and food was plentiful. Then the Maori, happy himself, enjoyed the shrill song of the merry cicada. In the hot days of February the Botanical Gardens in Wellington are alive with these insects; the air is literally throbbing and pulsating with their song. On the stem of one cabbage-tree I have seen twelve, close together, chirring and burring and theeping without intermission, and hundreds more round about. Nor do they all sing the same song. Nos. (1) and (2) are from Kapiti, and I am not certain that these were produced by tarakihi, as the song was not so vehement and shrill as the songs I have heard at Wellington. The vowels were all short (as in *net*, *tut*), and in the accelerated triplets the vowels seemed omitted, causing a sharper attack on each note; it is this sharp attack that causes the penetrating *churr*. The *d* sound is at times *t*.

There may be one triplet, two, or more. The speed is about five quavers a second. The crescendo on every G flat begins on the slur from the F. In (2) there was always a sharp sound like *clip* on the first *d* sound following the *churr*. The songs (3) to (8) were all sung at one time on the cabbage-tree stem referred to, and there were, besides, other songs; one

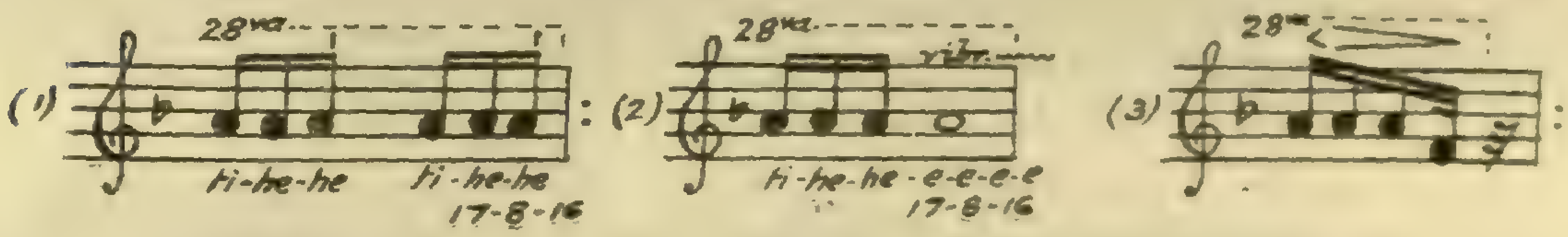


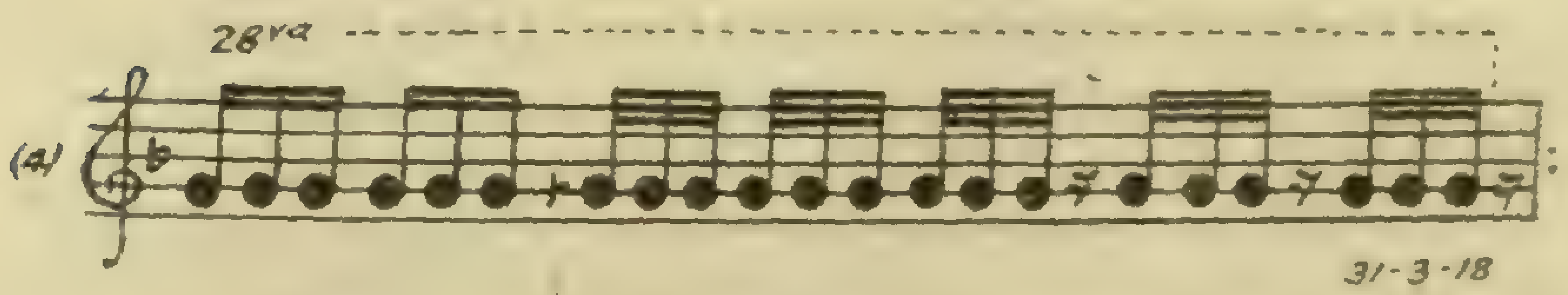
apparently did not interfere with another, and not one, apparently, had any consideration for any other. No. (3) consisted almost altogether of *click*. This sound is produced by the insect snapping its wings, each snap making a click. Usually the songs are punctuated with these snaps, but at times, as in this one, the snaps form the theme, ten or twelve to the second.

In (4) *clicks* were altogether absent. The notes here were long-drawn, two crotchets a second, the vocalization being a sleepy *theep, theep.* In (5) a very short *theep* preceded a long-drawn burr of two seconds duration on a lower note. In (6) there was an unbroken throbbing slur from A to E and down again, from fifteen to twenty beats a second in the throb, with a *click,* at the bottom of each wave, on the A. The insect sang on and on without intermission, two crochets in three seconds. This was varied as in (7), where there was an upward slur, but a sharp descent to the A. In yet another both slurs were omitted, as in (8). The song (9) was that of a solitary tarakihi singing at dusk, about ten semiquavers a second.

PIHAREINGA *(Acheta campestris).*

The song of the pihareinga is altogether different from that of the tarakihi. It is much softer, sounding as if coming from a great distance. The creature lives in the grass; and whereas the song of the tarakihi, which is arboreal, is heard only during a few weeks at the height of summer, the gentle song of the pihareinga may be heard throughout the year; even in winter, a warm day invites him to sing his quiet round. The song may be in triplets, as in (1), vocalized *ti-he-he,* or *chi-he-he.* When properly warmed up to his song there are few pauses, but the *ti-he-he* is followed by a long





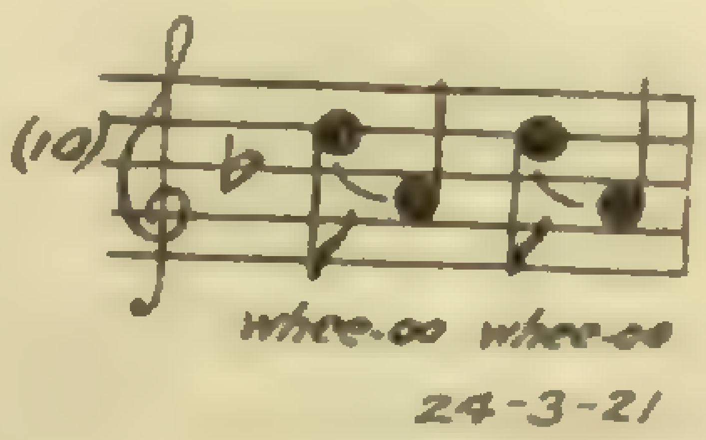
vibrato, as in (2). These were heard on a warm sunny day after cold weather. The notes may be in fours, making a quick continuous sound like the turning of a wheel, broken at times by the last note of the fours being softened, or dropped altogether. Very characteristic is (3), where the fourth notes drop in interval a tone. The notes are sometimes vocalized *ti-ti-ti-tu,* sometimes unvocalized, simply churry, sounding like a small wheel revolving rapidly—a fairy knife-grinder's wheel, the accent and sudden swell at the first note coming at the pressing of the pedal. At Kapiti one burred in triplets on G, dropping a quarter-tone for a time, then up again, and down, and so on, about ten semiquavers a second on the G and fifteen a second on the G half-flat, as in (4).

At Operiki, near Koriniti, Wanganui River, the pihareinga was very voluble during the last week of March (1921), maintaining a continuous *churr* on G for many minutes at a time, eight or ten notes a second, in the grass of the hillsides. The sound was shrill, but soft and pleasant—not nearly so penetrating as the *churr* of the tarakihi.

At Gisborne was heard yet another, whose song was of the quality of the pihareinga, a continuous *churr* on one note. The note was louder, however, but not shrill, and was heard throughout the summer night. I have heard the pihareinga only by day.

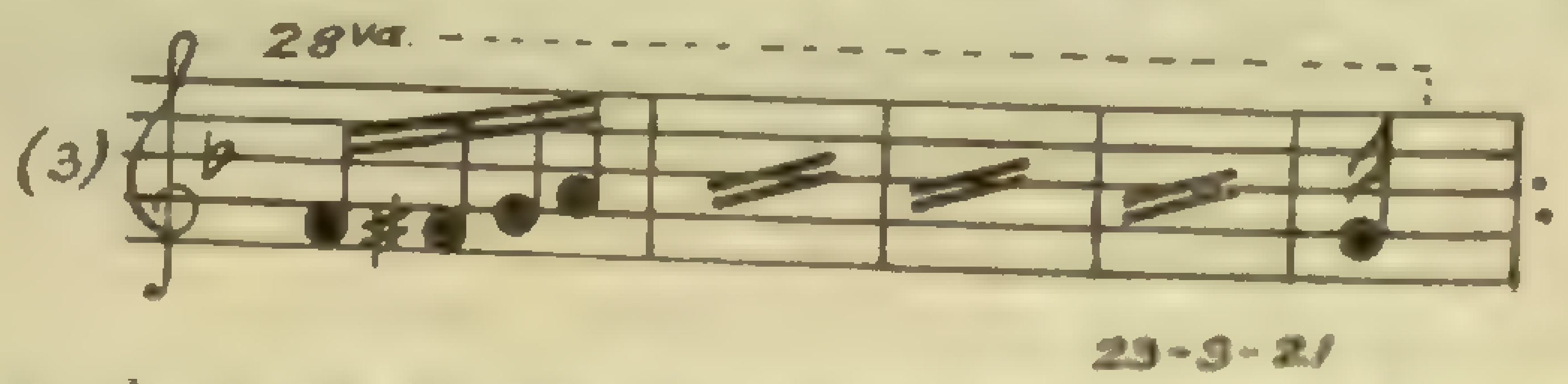
Ruru *(Ninox novae-zealandiae)*.

A common call of the ruru (morepork) at Koriniti, Wanganui, was as in (10), vocalized *whee-oo whee-oo.*



Miromiro *(Petroeca toitoi)*.

The miromiro (white-breasted tit) was common up the Wanganui River, a pleasant song being (3), the four notes, about eight a second, being repeated



from two to four times as shown, sometimes followed by a single G. This song was at times preceded by a higher note, C, repeated four times or more, semiquavers separated by semiquaver rests.

Tui *(Prosthemadera novae-zealandiae)* and Bell-bird *(Anthornis melanura)*.

It is usually the tui that is credited with the harsh interjectory noises likened to coughs, sneezes, &c. Many of these have been recorded in tui songs, and some in bell-bird songs. Whilst staying at the various Maori settlements on the Wanganui River in March–April, 1921, however, especially whilst at Pipiriki, it was found that the bell-bird uttered these harsh sounds with even greater frequency than the tui; in fact, during one day's walk, when the sounds were heard continually, they were uttered by bell-birds in every instance where the bird was seen. This is further evidence for the contention that it is never safe to record a note as of a tui or bell-bird unless the singer be actually seen.

INTRODUCED BIRDS.

The fear of the extinction of the indigenous birds led to the recording of their songs. No such fear is felt on account of the introduced birds, and the task of recording their songs has not been undertaken. Since it has been said, however, that it is not possible to record their songs in our musical notation, a few have been recorded from time to time, partly to refute the statement, partly that the notes may be compared with those of the same birds elsewhere.

Californian Quail *(? Callipepla californica)*.

The common call of the quail on Kapiti was as in (1) A, and I can think of no vocalization that is nearer it than the words *Miss Harper*. This was also the vocalization of quail-calls heard at Motueka. At times the third note was omitted, as in (1) B, and at times the call was on one note, as

in (1) C. A variation not so often heard was (2), where the vocalization was *Esther how.* Neither the pitch nor the vocalization of the call of the quail agrees with that given by Schubert in "Der Wachtelschlag" ("The

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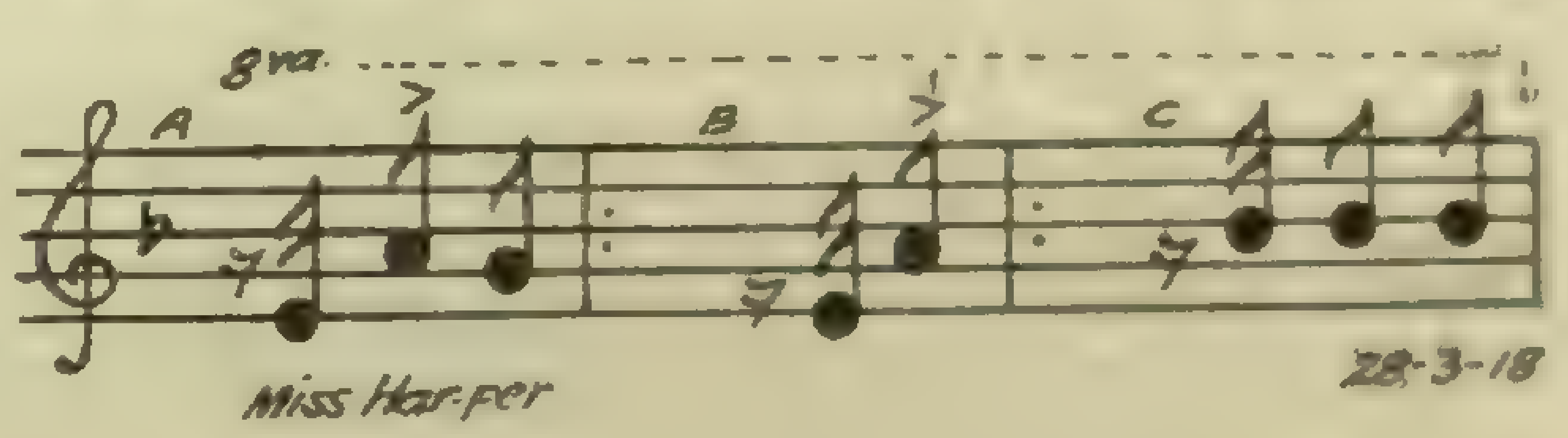

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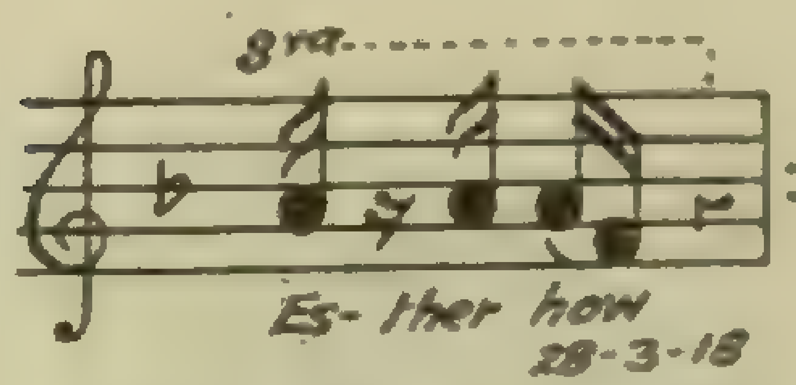


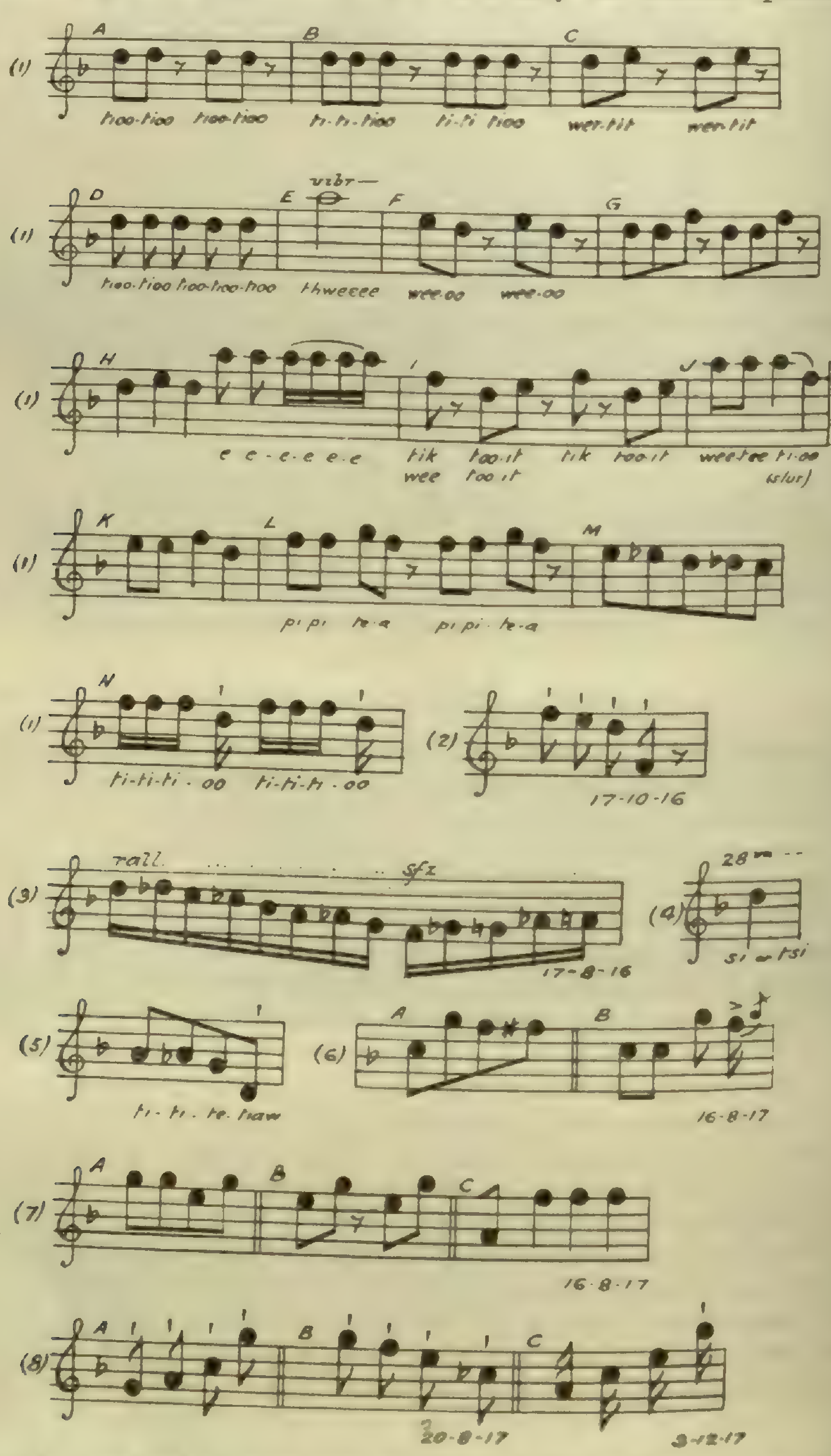
Quail-cry"), nor with that given by Beethoven in his song bearing the same name. Schubert gives the pitch usually as E, Beethoven as B, and both vocalize the notes as *Fürchte Gott*, the notes in both instances being

In the variant (1) C there is a slight approach to this. Beethoven uses the same notes in his "Pastoral Symphony," but they are there pitched on D.

THRUSH *(Turdus musicus).*

Soon after moulting is over—say, early in May—the thrush may be heard singing. The birds that start thus early are, I think, old birds, or birds of more than a year old, and their song is full and finished. Young birds start later, and they may be heard regularly practising. One year I heard the first full song on the 30th April, and on the 21st May I saw a young thrush beginning to learn his song. He sat on the top of a low tree overlooking a scrub-bush-grown hillside, and first practised, over and over, the notes of (1) A, being two simple notes of the same pitch, divided by a pause. His next notes were (1) B, where the same notes are in triplets instead of pairs, and these were followed by the first interval (1) C. The vocalization A and B was usually *ti* or *tioo*, but when the interval separated the notes the vocalization was *wer-tit.* Next day the fives of (1) D were practised, in addition to those already acquired. There appeared to be no order in the practising: the pairs of A might be uttered once, twice, or up to four or five times, but usually three times; then C or B once or several times, but B usually twice and C three times; then A again, or D, and so on by the hour. The bird was practising before I was up in the morning; he was still practising when I left for the town before 9 a.m.; while I was at home for lunch, and often when I returned between 5 and 6 p.m., there he sat singing these simple notes over and over. On my way to the town this season I passed five birds practising in this way, every bird having his favourite twig, where he might always be found when singing. On the second day E also was added—a very rapid vibrato, as though the sound were forced through a narrow slit, the membranous edges "giving" as the air passed. It was not a vocalized whistle like the other notes. On this day (22nd May) a downward interval (F) was added, the vocalization again changing to *wee-oo*, and a combination, as it were, of A and C took

place, G, the interval, however, being a third instead of a second. These notes, too, were true whistles, full and rich in quality. The slower notes of (1) H were also whistles, the high notes, vocalized, somewhat resembling E, in that they sounded as if forced through a narrow aperture, the last four quickening to a vibrato. On the 25th May the familiar phrase I was



commenced, vocalized *tik too-it* (or *stick to it*), or *wee too-it* (or *we knew it*); and hereafter the song developed rapidly. Up till this day most of the new notes could be taken down, but combinations of three and four notes became multiplied, those recorded being those most often heard. The speed would be four to five quavers a second.

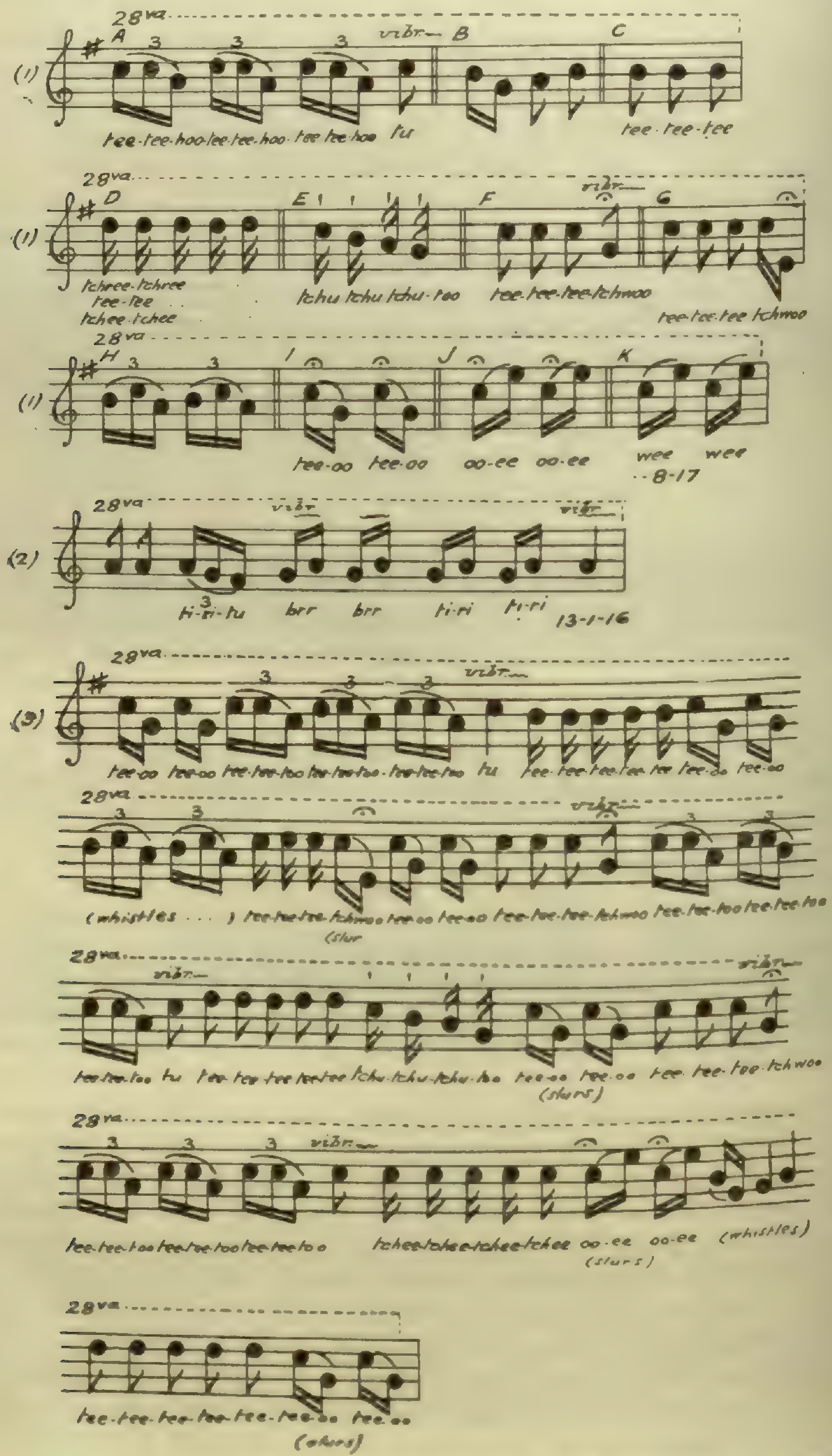
The phrases (1) A–N were taken down whilst going to or returning from work, and there is no doubt that, with sufficient time at disposal for, say, a week, the whole of the phrases used by the bird could be taken down; and, as the song is built up of these phrases, the song itself might readily be recorded. A few more notable phrases have been secured at various times, (2) being in clear, open, staccato whistles, the intervals clearly made. The fine chromatic run of (3) was obtained one evening, the close of a sunny spring day after cloudy, sleety weather—17th August, 1916. The full phrase was sung by two different birds in different parts of the shrubberies along Tinakori Road and the Botanical Gardens. There was a rallentando to the G, when the F was attacked sforzando, and the phrase ended with great spirit. The phrases (5)–(8) were common among the practice notes of August, 1917. The following close of a song by McGillivray well illustrates the vocalization of the notes:—

> Qui, qui, qui, kweeu, quip,
> Tiurru, tiurru, chipiwi,
> Too-tee, too-tee, chiu choo
> Chirri, chirri, chosee,
> Quiu, qui, qui.

SKYLARK *(Alauda arvensis).*

The individual phrases of the skylark's song may be noted in the same way as the thrush's, and the full song recorded. It will have been observed that, among the Maori birds, many have a number of definite songs besides phrases that form the material of song. Among the introduced birds I have seldom heard a definitely repeated song; the many definite phrases are repeated in indefinite combinations, so that whilst the phrases may be recognized, the combinations may not, though this may be because I have devoted more time to the song of the indigenes. When Browning says of the thrush, "He sings each song twice over," he refers to the phrases—not to the song. There is not nearly the variety in the lark's song that there is in the thrush's, nor has it the wide range of the thrush; in fact, it is surprising how few notes make up the inspiring song. In August, 1917, I sat on the uplands of the Tinakori Hills listening to the larks, and secured, I think, all the phrases used by one singer (1) A–K. The notes are rapid—about ten semiquavers a second. Many birds were singing, and though I watched and listened long, and have done so in many parts of New Zealand from the seashore to Alpine heights, I have not been able to corroborate the statement made by English writers that there is a difference in the song according as the bird is ascending, hovering, or descending. As I watched, the bird would mount, singing, circle for a while, poise with wings and tail widely spread, but apparently motionless, still singing whilst slowly floating downwards; then a turn of the vanes and a swift descent, the song ceasing as the descent began. I could, however, detect no difference in the phrases or combination of phrases, or in the tempo, or in the expression, that would mark ascent, hover, and descent. Constant changes of timbre there are, but the same changes irrespective of position. Sometimes the notes are whistles, sometimes they are vocalized, and differently vocalized, as shown. Pauses, slurs, vibratos, staccato notes, hurryings, and slackenings—all lend charming variety to the few notes employed. It has also been said that the notes keep time to the beating of the wings: I have been able to detect no such correspondence. The manner of combination of the phrases is shown in (3),

which scrap of song would take from ten to twelve seconds. The average length of song at this time of the year (August) was about a minute.

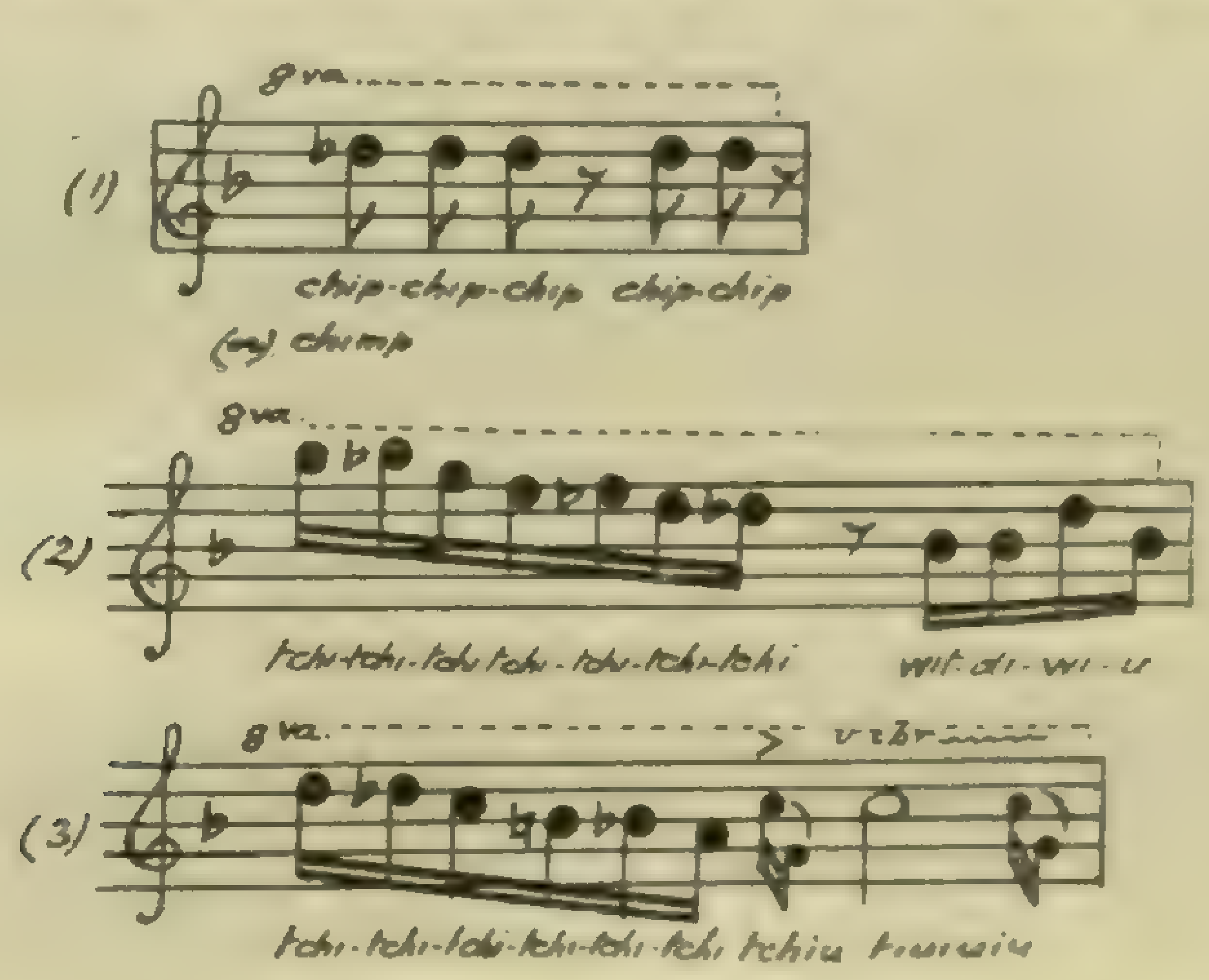


No. (2) are a few phrases from a song heard on Kapiti. The vocalization of the song is very well reproduced by Du Bartas in the following:—

> La gentille allouette avec son *tire-lire*
> *Tire lire a lire et tire-lirant tire*
> Vers la voute du ciel, pecis son vol vers ce lieu
> Vire et desire dire adieu Dieu, adieu Dieu.

CHAFFINCH *(Fringilla coelebs)*.

This was the favourite cage song-bird in Germany. Twelve distinct songs were recognized and named, and of these twelve the second, fourth, sixth, and ninth had two varieties, the seventh and eighth had three, and the fifth had five varieties—all named. The names were apparently given for varied vocalizations as well as for different themes, and the bird was a favourite not only on account of his vigorous, cheerful song, but also on account of his bold bearing and fine colouring. The usual call-note is, as in (1), a single note, or in sets of two or three, uttered sharply at

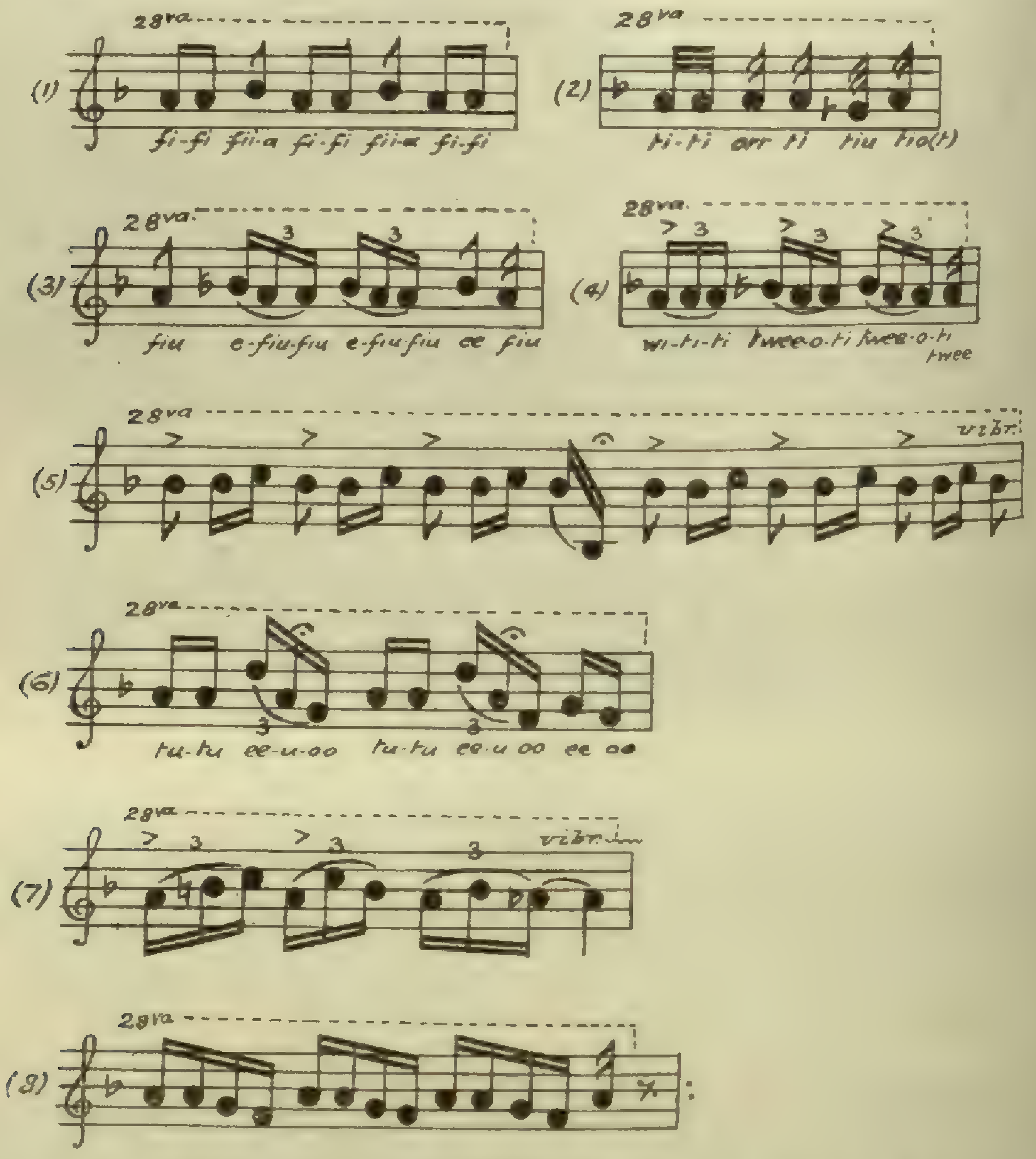


the rate of about five a second. This is probably the call *fink*, which is said to have given the bird its name. The most usual song about Wellington is (2), a chromatic drop of varied interval followed by a pause and a final flourish of varied vocalization. This song occupies from a second and a half to two seconds in utterance. In (3) is shown a characteristic terminal flourish.

HEDGE-WARBLER, OR HEDGE-SPARROW *(Accentor modularis)*.

This is the only one of the British warblers that has been acclimatized. The song is a quick vocalized warble, generally hovering about one note. At times intervals are attempted, and these are often less than semitones. The vocalization is much varied. Whilst there is a great deal of indefiniteness in the song, and much of it appears to be sung in a haphazard, absent-minded way, there are many phrases that are apparently the result of a wakening perception of melody in the bird, and not of blind accident. The phrases (1)–(4) show a hovering about one note, and much of the song consists of nothing but such hovering—very pleasant, but little varied except in vocalization. Yet even phrases like these appear to present themselves with definiteness to the bird's ear, for at times one or other or their like may be repeated. The phrase (2), for instance, sung in about a second, was repeated many times with an interval of a second between the repetitions. Phrase (3), and its variant (4) were repeated in a similar way for minutes at a time. Whilst there is little variation in the outline of (5), the strain contains a definite theme, and it is in perfect common time, warbled allegro, the octave slur and the vibrato note ending alternate bars. There is a curious elusiveness in the tempo of (6), caused by a slight pause on the second note of the triplets: the definite intervals are also unusually wide. The tempo is quite definite

in (7), a phrase which displays considerable art. The first two triplets were accented on the first note, but in the third triplet the accent was omitted, the first two notes of the triplet were slightly hurried, and a trace of the lost accent was heard on the A flat. The earliest song heard



in 1917, on 27th March, was (8), also in perfect time—a bright, cheerful song, sung at the rate of eight semiquavers a second. The song was unusually early, as the hedge-warbler generally starts singing in Wellington about July, the last month of winter, singing on till the moult in the hot weeks of January.

PSYCHOLOGY OF BIRD-SONG.

Assuming bird-song to be a secondary sexual character, many facts can be brought forward in support of the assumption. Regarded from another point of view, however, bird-song may be seen as a characteristic quite apart from sex, but upon which on occasion sex seizes for its own end; and many equally cogent facts can be brought forward in support of this view. Many emotional elements mingle at the source of song, be it bird-song or human song, the sex-emotion being but one. Song is a flowering of the emotions, as speech is a flowering of the thought.

Mudie (MF, vol. 1, p. 273 *et seq.*) notes "the connection between the song and the plumage, and the silence and the moult"; and remarks that it "shows that the whole bird is subject to some general law, which, though it lies deep beyond the power of our divination, governs

even the minutest circumstance—the production of a new spot or gloss on a feather, the reddening of a comb or a wattle, or the inspiration of courage into birds naturally timid. The birds, in fact, blossom in spring as well as the plants, and when the purpose of nature is accomplished the bloom of the one is shed as well as that of the other. But if the purpose of nature in continuing the race is not accomplished the bloom lingers." In the last sentence Mudie reveals his point of view—he regards the song as sexual; but he is wrong when he says the bloom is shed when the purpose of nature (or what he assumes to be the purpose of nature) is accomplished: song in birds extends before and beyond the breeding season; in some birds, like the thrush, it is interrupted only by the moult. No doubt it is finer during the breeding season, but then it does but augment with the general flowering of that season.

It is supposed that caged birds sing for a far longer period than they do in nature, not because their surroundings are more conducive to song, but because the functions that called the song into being have not been fulfilled. Mudie contends that no caged bird sings with the full power and freedom of the woodland song. Bolton, on the contrary, asserts (BH, vol. 2, pp. 28–29) that "in its wild state the nightingale sings only during some ten weeks of the year; but in confinement will continue its song for nine or ten months; and a caged nightingale sings with infinitely more sweetness than those abroad." In this "sweetness" Mudie recognizes "a blending of the cry of irritation and distress." The two writers hear different qualities in the same song, each influenced by his own feelings.

A consideration of the period at which the song of various birds is at its perfection makes it evident that there is a mingling of various emotions in that passion of melody. The song of the nightingale continues day and night through the period of incubation, but ceases almost immediately on the hatching of the brood, when the sweet notes degenerate to a guttural croak. If, however, when the song has thus ebbed away, the nest be destroyed or its contents removed the lost voice is speedily recovered, and the song is heard once more (TB, p. 149 *et seq.*—quoting from Newton's Dictionary). It would appear to be altogether a mating and brooding song; but there are modifying facts to follow. The thrush, on the other hand, sings through the greater part of the year; and other birds, such as the robin and the water-ousel, sing during autumn as well as summer; and on this fact Darwin comments (DD, p. 370), "Nothing is more common than for animals to take pleasure in practising whatever instinct they follow at other times for some real good." From the other point of view it might be said, Nothing is more common than for the sexual instinct to seize and use as incentive some quality that at all times gives pleasure.

Is it a sexual instinct that impels the male birds to precede the females in their migration? The males of most of the summer wood-warblers appear as much as a fortnight before the females (WW, p. 59), and immediately commence their song. The song is at first immature, gradually reaching its full perfection during the time the males are alone (CW, pp. 115–16). It is hardly likely that they sing without experiencing pleasure from their song, even in the absence of the females: can it be supposed that their pleasure is heightened by anticipation? Have they anything of the human emotion whereby

> We look before and after;
> We sigh for what is not?

It is probable that the song is an indication of the awakening and the stirring of sexual emotions, as the scent of the flower is an indication that it is ready for the touch of the pollen-grains; but the song comes with the emotions, not because of them—or why are so many birds songless? It is during this period of probationary song that the bird-catchers trap the nightingale. The birds then caught may be trained to become fine songsters; but if, after the arrival of the females, a male be trapped whose singing has secured him a mate, not only will he be of no use as a cage song-bird, but he will in all probability die in confinement (YH, vol. 1, p. 319, ed. 3). Bechstein (BC), an ardent bird-fancier, though he can hardly be called a bird-lover, states that the nightingale's song is perfect before the arrival of the females, and that it deteriorates immediately on their arrival; so that, if it be a mating-song at all, it is rather a prothalamium than an epithalamium. It will be noted that Yarrell simply assumes that the singing of the male has secured him a mate. If the singing did so, or could do so, why should the song deteriorate at the very time it should be at its highest excellence? May it not be that the increased spring-vitality finds expression in song whilst the females are absent, and is diverted to the passion of mating when the females do arrive? One reason for the song being usually confined to the male is that the superabundant energy that in the male is transformed to song or to colour, in the female is absorbed in egg-laying and rearing. To this idea objection can also, of course, be urged by pointing out exceptions.

Further, if the precession of the males be a sexual instinct, it is not undertaken solely in order that the song may be practised without the distraction caused by the presence of the females, since the males of most migratory birds, whether singers or not, appear before the females (DD, p. 212). So that the fact that the blackcap, nightingale, and other warblers practise their song before the arrival of the females would appear to be as much incidental as significant. Swallows usually arrive in pairs (WW, p. 59).

Is the song to be considered sexual when both sexes sing, as do the tui and bell-bird? I have detected no difference in the songs of the male and female tui. The song of the male bell-bird is quite different from that of the female, but the song of the latter is heard far more frequently; I have heard the song hundreds of times, but have heard the song of the male only twice.

Is there a single recorded instance (except, perhaps, amongst caged birds) of a female having shown that the song of the male attracted her? I have never seen a single instance. Twice I have seen a male blight-bird start his song, the female immediately flying to the attack, compelling him to desist. I have seen a tui sidling towards a female, singing a charming whisper-song—and the female sought refuge in flight. When the cicadas are singing in their thousands, never once has a female been seen to approach the joyous males; neither has a female thrush ever been seen to approach the male singing by the hour on the tree-top; nor has the song, either of cicada or thrush, lessened in consequence, either in volume or charm. If it be said that the female shows subsequently that she acknowledged the attraction, how is it known?

Birds appear to sing in emulation; and, whilst emulation may indirectly be connected with courtship, birds will sing in emulation when courtship has ended successfully in the securing of a mate—when it may, indeed, be said that emulation has passed in a natural course to exultation.

Bolton (BH, vol. 1, p. 15) writes of the blackbird, "When two are singing at the same time within hearing of each other they will contend in song like the nightingale, each keeping silence alternately till the other has repeated his song." Birds are often matched in song by fanciers, and will at times, at such contests, sing themselves to death; and some naturalists believe that singing is almost exclusively the effect of rivalry and emulation (DD, pp. 369–70). The editor of White's *Selborne* remarks (WS, p. 123) in a note that the song of the swallow exhibits no appearance of emulation, but that "it seems to proceed from feelings of happiness and complacency, which cannot be mistaken. I like to watch it darting now and then to its nest, and uttering that little note of love which is responded to by the female whilst she is performing her task of incubation . . ." On this point, how is it known that the brooding female pays special regard to the song of her mate? How is it known that she does not pay equal regard to the song of every bird singing within hearing? There is always the human analogy; and the human analogy, if we be honest, will lead us to most varying conclusions.

Again, is it sexual desire, or emulation, or pleasure that induces one bird to imitate the notes of another—more, to incorporate the songs of others into its own, with characteristic modifications, as is done by the blackcap? This imitation is even said by one writer (YH, vol. 1, p. 420, ed. 4), to detract from the excellence of the bird's natural song. The imitation of other sounds by the starling is constantly referred to. The sedge-warbler is said to imitate the notes of other birds, particularly those of the sparrow, swallow, and skylark, and has often been called the English mocking-bird. "It executes its imitations in rather a hurried but very pleasing manner" (BH, vol. 2, p. 69). True mocking-birds show the extreme to which imitation may be carried; but if imitation detract from the quality of the song, would that not be a fatal disadvantage were the song purely sexual? A certain amount of imitation is, no doubt, common enough, and Witchell (WE, pp. 165 *et seq.*) quotes many writers to this effect, the mimicking birds being the redstart, blackcap, sedge-warbler, marsh-warbler, reed-warbler, whitethroat, skylark, whinchat, stonechat, wheat-ear, greenfinch, &c.; and Witchell himself (WE, pp. 195 *et seq.*, and 201 *et seq.*) produces tables showing various bird-notes imitated by thrush, robin, skylark, starling, sedge-warbler, the different kinds of birds imitated by these five, numbering respectively thirty, twenty-two, fifteen, sixteen, and eleven. He also records the imitation of the barking of a dog by a starling, and even the bleating of a sheep by a skylark!

The whole question of imitation, or mimicry, is, however, debatable. Certain notes and combinations of notes may be common to many species; certain ones are without doubt common to several, and many apparent imitations may in reality be natural notes; and of many it may be difficult to say which bird is the imitator, which the imitated.

No doubt imitation plays an important part in the education of the young bird, though it has not been shown why a young bird will imitate the song of its own species rather than that of another. Written evidence is again wildly confused. Romanes (RM, pp. 222–23) quotes Couch to show that "singing is certainly instinctive." Hudson (HN, pp. 89 *et seq.*) shows that at least the understanding of the significance of certain cries is instinctive. The Rev. W. Herbert, on the other hand (WS, note on pp. 131–32), makes very full observations on the learning of song by young birds, the gist of the observations being against the song being instinctive.

It may be that the knowledge of the song does lie deep within—unexpanded—in a bud, as it were, which opens in response to the throbbing of the song of the species; so that the free young bird adopts the song that finds the readiest echo in its own breast. Young birds vary in the docility shown in learning the song of other birds—see Witchell (WE, pp. 175–76), Wood (WN, p. 59), Bolton (BH, vol. 1, pp. 11, 30, 56)—the acquired song smothering, or partially smothering, the natural song. The young cuckoo shows no docility, but on leaving the nest responds to the natural song of its kind.

Human song gives wide expression to the emotions of love, of praise, of joy, of good-fellowship. It surely would be too much to say that the source of the whole is in the sexual emotion, the songs of worship and good-fellowship being merely secondary blossomings of the primary emotion; rather it would be nearer the truth to say that song is a natural expression of emotion, the expression being most developed, most exuberant, when the spring-tide of the blood is flowing; and that in song the sexual emotion finds a powerful ally, seizing upon it, but not creating it, for the furthering of its own especial and occasional end. That which is true of human song is true, in a large degree, of bird-song; nor does this ascribe to birds a greater aesthetic sense than has already been ascribed to them by those who maintain their song is purely sexual.

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ART. 48.—*Miramar Island and its History: How Motu-kairangi was discovered and settled by Polynesians, and how, in Times long past, it became Miramar Peninsula.*

By ELSDON BEST, F.N.Z.Inst.; Ethnologist, Dominion Museum.

[*Read before the Wellington Philosophical Society, 19th October, 1921; received by Editor, 20th October, 1921; issued separately, 22nd June, 1923.*]

THE history opens with accounts of episodes in the adventurous lives of four famous old Polynesian voyagers, named Kupe, Ngahue, Toi, and Whatonga. These old-time ocean-rovers were members of a race that produced the most daring and remarkable neolithic deep-sea voyagers of whom we have any knowledge. We do not know at what period the Maori people entered the Pacific region, but we do know that for many centuries they ranged far and wide across a vast ocean area of some four thousand by six thousand or seven thousand miles in extent. The Maori claims close kinship with the natives of Hawaiian Isles, as shown in common traditions, ancestors, myths, language, and many other parallels. Moreover, should the Maori land at Nukuoro Island, in the far-away Caroline Group, he would assuredly claim the folk of that island as brothers, so closely allied are the dialects of Aotearoa and Nukuoro. Westward and southward from Nukuoro, separated by a sea-path of some seven thousand miles, lies the remote Easter Island, held by an outpost of the far-spread Polynesian race speaking the Maori tongue.

The men who ranged the vast Pacific Ocean in their lean carvel-built craft, who explored its far-flung archipelagoes, and settled so many of its innumerable islands, were the men who discovered New Zealand. Century after century they sought the unknown, and forced lone seas to give up their secrets. Ever listing to the lure of Hinemoana the Ocean Maid and to the call of the unknown, ever prompted by love of adventure and the mysterious beckoning influence of far sea-horizons, they hoisted their rude mat sails on primitive craft, and rode down the endless lilting sea-leagues of half a world.

These were the men who laid down the sea-roads we still use, who followed the rolling *ara moana* with a fine faith in their own powers and in those of their old-time gods. They lifted unknown ways before the steady trade-winds; they followed the regular roll of the waves beneath clouded skies; they drifted down the long rivers of the ocean as others drift down earth-bound rivers. They held their course by the shining sun and by pale Hina; they lined their path across the heaving breast of the Ocean Maid by the world-old stars above; they swung their reeling prows south of Canopus, and Venus, and the red sun, and so discovered these isles of the hidden south.

A thousand years ago—forty long generations of men—two deep-sea voyagers named Kupe and Ngahue left their far-distant homes in eastern Polynesia and sailed down into the unknown Southern Ocean. Their vessels were named "Matahorua" and "Tawiri-rangi." During this voyage they made the land near the North Cape of New Zealand, where they sojourned a while. The first sign of land seen was a white cloud that overhung it, and this was first seen by the wife of Kupe of

"Matahorua." She drew attention to it by crying out "*He ao! He ao!*" (A cloud! A cloud!)—and so New Zealand gained its earliest name. The North Island was named Aotea (the White Cloud)—often called Aotearoa.

The voyagers ran down the east coast of the North Island, sojourned a space at Castle Point and Palliser Bay, then came on to Port Nicholson, where they landed at Seatoun, a place that seems to have been formerly known as Maraenui. At that time Miramar was an island, the sea flowing across the present isthmus at Kilbirnie: on this lone island the explorers camped. Several place-names commemorate the name of the chief man of the expedition: thus the foreshore at Seatoun is Te Turanga o Kupe; the Pinnacle Rock is Te Aroaro o Kupe; Barrett's Reef is Te Tangihanga a Kupe, also Te Rarangi a Kupe. Somes and Ward Islands are said to have been named Matiu and Makaro, after two of Kupe's daughters; two other daughters, Mohuia and Toka-haere, having their names perpetuated in two isolated rocks near Te Rimurapa (Sinclair Head).

Moving on from Seatoun, the voyagers camped at Sinclair Head in order to lay in sea-stores of dried fish and shell-fish. They then moved on to Porirua, thence to Mana Island, and across Raukawa, or Cook Strait. They visited the west coast of the South Island, where they are said to have discovered greenstone at Arahura—a discovery that was of great benefit to the Maori of later times. They are also said to have slain a *moa* at that place. Eventually these courageous navigators sailed for Rarotonga and found their way back to the Society Islands. There the story of their voyage, with sailing directions for these islands, was preserved by succeeding generations, which enabled voyagers of later times to find their way to the land of Aotearoa.

It is unfortunate that no data have been collected as to the aspect of this harbour at the time of Kupe's visit. Surely the *moa* must have ranged these solitudes in those far-off days, for its bones have been found here under conditions that seem to show that it had furnished a food-supply to early inhabitants. Other disappointments of this nature have been experienced—for what interesting notes would have been gained from Cook had he entered the harbour on the 2nd November, 1773, when he anchored for two hours one mile from Barrett's Reef; or from D'Urville, who attempted in vain to enter in 1827!

There is no evidence to show that the Mouriuri folk, the first inhabitants of New Zealand, ever occupied this district. If they did, then it would probably be at a time subsequent to the arrival of the first Polynesian colonists. When the latter arrived here, the Mouriuri people, we are told, were living as far south as the Wai-ngongoro River.

The next event connected with this district, as gathered from Maori tradition, is the coming of a party from the Mahia district with the intention of seeking a home in these parts. The story is that at a certain time, away back in the thirteenth century, a gale of wind sprang up somewhere off the western coast-line of South America, and swept through the islands of eastern Polynesia onward as far as Samoa. That gale it was that brought the first settlers to Miramar. The explanation is as follows:—

Whatonga, a resident of Tahiti, had, with a number of companions, been carried away from that island by the gale. His grandfather Toi sailed in search of the waifs, and visited many islands during his search. He found some of them at Pangopango, in the Samoan Islands, but not his grandson. Continuing his search, he at length reached Rarotonga, and, finding no trace of his young relative, he resolved to sail for the land

of Aotearoa, discovered by Kupe ten generations before. Said Toi to Toa-rangitihi, a chief of Rarotonga: "I go to seek my lost offspring at the land discovered by Kupe in far ocean spaces. Should others seek me, tell them whither I have gone, for truly I will reach that land or be engulfed in the depths of Hinemoana." The courageous old sea-rover swung the prow of his long-boat to the south-west, and sailed down five hundred leagues of open sea to the land of Aotearoa.

He did not make a true landfall; he missed New Zealand, but sighted the Chatham Isles. Eventually, however, he came to land at Tamaki, where the City of Auckland now stands. After sojourning for some time among the aborigines at that place, Toi and his companions, sixty in all, sailed to Aotea (Great Barrier Island); thence to Tuhua Island, in the Bay of Plenty; eventually settling at Whakatane. There, at Ka-pu-te-rangi, on the cliff-head overlooking the river-entrance, the disappointed, sea-worn old Polynesian voyager came to rest. Probably he did not feel equal to making another voyage across rough seas in the primitive craft of those far-back times. So Toi of Tahiti settled in the Land of Awa.

Meanwhile Whatonga had, after many adventures, found his way back to Tahiti, where he learned that Toi was still absent in search of him. He resolved to set forth in quest of Toi, and so sought a suitable vessel for the making of a deep-ocean voyage. He acquired from one Turangi a vessel named "Te Hawai," renamed it "Kurahaupo," and fitted it for a long voyage. The vessel had three *haumi*—that is, the hull was composed of four pieces; it had twenty-six thwarts, two bailing-wells, and two anchors. Whatonga selected a crew of hardy seafarers inured to deep-ocean work, resolute wayfarers on the sea-roads of the wide Pacific. The top-strakes were lashed on, the splash-boards fixed, vegetable gum, shark-oil, and ochre being used to dress all the timbers. Fifty-and-two paddlers were selected, also four ship-tenders, two anchor-tenders, four sail-tenders to attend to the sails, two steersmen, and two fire-tenders. Thus sixty-and-six were the persons forming the crew of "Kurahaupo," and it is known that a few women were also on board. The canoe was hauled to a *tapu* place, and solemn ritual was chanted over her to place her under the protection of the gods. The symbols of the gods Maru, Tunui-a-te-ika, and Ruamano were placed in the stern of the vessel. Then, ere the sun appeared over the horizon, "Kurahaupo" was hauled down to the beach and launched, the crew took their assigned places, and with wailing song, and tears, and farewell cries, these gallant ocean-rovers left their island home for ever. Whatonga of Tahiti, the Seeker of the Searcher, he who was to be the first settler of Wellington and designer of the first village at Miramar, had lifted the long, rolling trail of three thousand miles that was to lead him to Maraenui on Seatoun beach.

He and his companions made their landfall near the North Cape, ran down the west coast to Tonga-porutu, and there heard that Toi had settled at Whakatane. Then they sailed northward, rounded the North Cape, and ran down to Whakatane, where the long double quest was at last ended in the meeting of the two dauntless traversers of the *ara moana*.

Whatonga did not settle in the Bay of Plenty, for it was held by many of the aboriginal Maruiwi. He led a party round the east coast, and eventually settled at Nukutaurua, in the Mahia district. Here he lived until he had become an old man, and his followers, by intermarriage with aboriginal women, had increased considerably in numbers. It was then that Whatonga sent his two sons, Tara and Tautoki, southward on an

exploring trip to seek lands whereon to settle with their followers. The two young men came down the coast with a party, examining the country as they came, to Castle Point, to Palliser Bay, and to Port Nicholson. They camped for some time at Para-ngarehu (Pencarrow Head), then moved on to Porirua, to Rangitikei, and so returned home by way of Taupo, Titi-o-kura, Mohaka, and Te Wairoa.

The description of Wellington Harbour given by Tara to Whatonga, as preserved in tradition, is highly interesting, but too long to be given here. Of special interest are two remarks concerning Miramar, or Hataitai, for they show clearly that it was an island at that time. Inasmuch as lines of descent from Whatonga show twenty-eight generations, we may say that the coming of Tara to Port Nicholson occurred early in the thirteenth century. In his report to Whatonga, Tara said: "The largest island is situated to the southward, where the two channels connect with the ocean. The two small islands are desirable places on which to live." Later on we come to this statement: "Then they went to examine the entrance of the ocean, and the big island between those two channels, after which they returned to Matiu (Somes Island)."

When Tara and Tautoki came south with a considerable party of followers to settle at Port Nicholson old Whatonga came with them. They came down in the month of Akaakanui (December) by sea, and put in at Castle Point, where they sojourned a while. Their next stopping-place was at Okorewa, in Palliser Bay, where the party took one of their canoes up to the Wairarapa Lake to facilitate the examination of the surrounding lands. They then came on to Port Nicholson, which was nameless at that time, and camped on Somes Island; and the lone shores of this harbour were never again to know primeval solitude, for man the rover had arrived. So it was that, seven hundred years ago, a wind sweeping westward from South America had brought about the coming of Whatonga the sea-rover, and the settlement of Wellington Harbour.

The first task of the migrants was the erection of houses on Somes Island and the planting of crops. The materials for the houses were obtained on the mainland, and three framed houses (*whare whakanoho*), named "Haere-moana," "Aotearoa," and "Te Pu o te tonga," were erected. Each of the brothers had a following of one hundred, so that these first settlers of Wellington were two hundred in all. Whatonga remained here until the autumn, when he returned to his northern home. Prior to his departure he advised his sons to settle permanently on the largest of the three islands—the one we may now call Miramar Island, for it has not yet been named. The old sea-rover accompanied his sons to this island, where he selected a site for a fortified village on the ridge above Te Puna a Tara (the Spring of Tara) in Worser Bay. He marked out the lines of the stockades, and gave his sons detailed instructions how to build the *pa*, and also much advice as to their future activities. All this has been preserved in tradition, and is of much interest. Having seen his sons settled at Port Nicholson, Whatonga returned to his home at Nukutaurua, and so passes out of the story.

The first band of Wellington settlers now set to work to erect the *pa* on the Seatoun heights. The necessary timbers were procured up the Hutt Valley, were hauled and carried to the river, and then floated down and across the harbour to Miramar Island, then dragged to the site of the new village. The defensive works consisted of three lines of stockades—for earthwork defences were almost unknown in this district, there being too much rock for the wooden implements of the Maori. One of the lines

of stockades was a *pekerangi*, in which the palisades are lashed to the rails, but do not reach the ground, there being an open space of about 1 ft. below them. Next came the *matahao*, a stockade erected in a slanting position, leaning outwards. Inside that was the *katua*, or main stockade, composed of heavy timbers. The main posts were 5 fathoms in length, and the secondary posts 3 fathoms, while the palisades were 2 fathoms. The *waharoa*, or entrance-passage to the *pa*, was stockaded on both sides. There were two fighting-stages above the entrance gateway, and others on either side of the *waharoa*. The approach to the water-supply was also defended by stockades. Possibly this water-supply was the spring on the western side of the ridge. The two principal houses in the village were named " Raukawa " and " Whare-rangi "—the first after the Maori name of Cook Strait, and the second after the site of " Wharekura," a sacred building in the land of Uru, the original homeland of the Maori race.

This fortified village was named Te Whetu-kairangi, and Miramar Island was called Motu-kairangi. The eastern channel (the present entrance to Wellington Harbour) was named Te Au-a-Tane, while the western channel, that flowed across the present Kilbirnie Isthmus, was given the name of Te-Awa-a-Taia. In much later times, when Motu-kairangi became a peninsula and another people occupied the district, this peninsula was known as Hataitai. By this name it was known until the arrival of Europeans, when it was named Watt's Peninsula, and later it became known as Miramar—so named after a place on the shores of the Adriatic.

Wellington Harbour was named after Tara, son of Whatonga, who was the son of a Mouriuri woman, an aboriginal. Many of the crew of " Kurahaupo " had married aboriginal woman at Maketu, the place where Rua-kapanga, brother-in-law of Toi, had been so amazed by the sight of a number of *moa*, a creature that was not then extinct. For the euphonious name of the harbour, Te Whanga-nui-a-Tara (The Great Harbour of Tara), we have to thank Te Umu-roimata, wife of Tara. He himself intended to call it Tawhiti-nui, after one of the old island homes of the Polynesian folk.

Te Whetu-kairangi was held to be an important village, hence it was placed under the protection of the gods Tuhinapo and Tunui-a-te-ika. The *mauri* of the *pa* was represented, as usual, by a stone, which served as a talisman, and as the shrine or abiding-place of the gods. Such symbolic objects were much used by the Maori folk. In the case of a *pa* they were either buried at the base of one of the principal stockade-posts or concealed elsewhere. This is the material *mauri*: the immaterial *mauri*, as of man, is the physical life-principle.

Some time after the erection of the village, Tautoki left Tara in possession, and moved across Te Au a Tane to Para-ngarehu (Pencarrow Head), where he and his followers built another *pa*, and there lived. Tara was the eponymic ancestor of the Ngai-Tara tribe that occupied this district for centuries. Rangitane, son of Tautoki, was the eponymous ancestor of the tribe of that name that originally occupied the Wairarapa district and the southern part of the Hawke's Bay district.

When the Ngai-Tara folk increased in numbers some family groups settled on the mainland, and these lived in three stockaded villages on the range known as the Ranga-a-Hiwi—the range extending from Point Jerningham and Mount Victoria to Island Bay. The Wai-hirere *pa* was situated on Point Jerningham, the native name of which is Omaru-kai-kuru—which name seems to denote a remembrance of the breadfruit of Polynesia. The Akatarewa village was built on the summit of the ridge

south of Mount Victoria, while the *pa* called Uruhau was on the hill overlooking Island Bay. The old name of Mount Victoria was Matai-rangi, but in after-times it came to be known as Tangi-te-keo. Possibly this *keo* should be *keu*, an old name for wind: certainly the winds may frequently be heard on that exposed peak. The cultivations of the people were situated at Kirikiri-tatangi, at Maraenui, both on the shores of the Au-a-Tane; also on the mainland west of the Awa-a-Taia; at Hari-whenua (Te Aro Flat), and elsewhere.

At this period the Muaupoko tribe was living in the Otaki district. One Whiri-kai marched north with a party of raiders to attack them. On his return he brought three captives—a woman named Hine-rau, and her two children: these he handed over to Pakau, chief of the Uruhau *pa*, as a relish, to impart a flavour to his *kumara*. Te Rangi-kai-kore, chief of Wai-hirere, was present at the time, and was indignant at this action. He said to Pakau: "Man! should a person be doomed to die three deaths—the ravished home, the treatment as merchandise, and being eaten by you? Surely this is unjust." Then, turning to the slave, he said: "Young woman, arise; let us and your children seek the shelter of Te Whetu-kairangi, the refuge of mankind." On arriving at that place, Te Wakanui, the chief thereof, said: "O friend Te Rangi-kai-kore! Go; conduct the woman and her children to their home. You are right; shall a person die thrice? [*i.e.*, suffer grievously]. They are yet alive; let them remain so; do not enslave them."

The above raid on Otaki led to serious reprisals. Te Kopara of Muaupoko sought assistance from Taranaki tribes, assembled a force of his own warriors, and marched southward to attack Ngai-Tara. When the *kowhai* was in bloom they reached the Harbour of Tara, and from the Wharau range, above Kaiwharawhara, they saw smoke rising at Te Wai-hirere, Te Aka-tarewa, Uruhau, Te Whetu-kairangi, Pae-kawakawa, Motu-haku, Makure-rua, and Wai-komaru. It was decided to march first to Uruhau.

Meanwhile two men, named Mohuia and Kaipara, had detected the invaders and given the alarm. Scouts were sent out, and, it being a moonlight night, saw the invaders marching along the beach at Kumutoto (now Woodward Street), their rear being at Waititi (Charlotte Street). Later, from Kaipapa (Viceregal residence) they saw them take the track to Uruhau.

Meanwhile the folk of Wai-hirere and Te Aka-tarewa had joined forces, and, shortly after the raiders opened their attack on Uruhau, they reached the scene of action and assisted in repulsing the enemy. Knowing their own inferiority in numbers, the local people then crossed Te Awa-a-Taia and fell back on Te Whetu-kairangi. All non-combatants were sent across Te Au-a-Tane to Para-ngarehu, while the fighting-men of that place came over to assist in the defence of Te Whetu-kairangi. The invaders, having burned the villages of Uruhau, Te Aka-tarewa, and Te Wai-hirere, and cremated the bodies of two of their slain chiefs at Haewai (Houghton Bay), betook themselves to the making of rafts whereon to cross the channel to Motu-kairangi.

The invaders invested Te Whetu-kairangi, one hundred men being stationed at Takapuna, one hundred at Kirikiri-tatangi, one hundred at Mirimiri, and one hundred at Kaiwaka, on the western side of the *pa*, near the lagoon. Efforts were made to burn the defensive stockades by piling masses of dry fern against them and firing them, but so diligent was the garrison in hurling whip spears from the elevated fighting-

platforms that this scheme failed. After the lapse of some time the invaders were much distressed during a severe southerly storm, for they were unable to procure food-supplies from the ocean. The defenders of Te Whetu-kairangi took advantage of the miserable condition of the raiders and attacked them at dawn. They succeeded in defeating them, and the invaders fled to the mainland, a number perishing in the crossing of Te Awa-a-Taia. So ended the famous raid of west-coast tribes on the land of Tara.

Such is the story of the original settlement of Port Nicholson, and Seatoun folk can claim that their corner of the realm of Tara was the temporary abiding-place of the heroic old-time Polynesian voyagers who sailed their open canoes for two thousand miles from far Tahiti to discover these isles, and also that it was the site of the first permanent settlement in the district. Truly, things have changed since the days when the stockades of Te Whetu-kairangi stood on the Seatoun heights, and bare-limbed barbarians looked down upon the restless waters of Te Au-a-Tane.

As with most Maori traditions, there are certain unsatisfactory features connected with the above story. The most prominent of these is this: If the district was uninhabited when Tara and Tautoki settled there, why should they have gone to the trouble of erecting defensive works round their villages? The clear statements that Miramar was an island at that period form the most interesting part of the legend. On the 2nd November, 1773, Miramar was a peninsula; at some intervening period Motu-kairangi had become part of the mainland. Was this due to a gradual rising of the land, or to an earthquake-shock lifting the land, as it did in 1855? Certain evidence brought forward by malacologists seems to point to a sudden upheaval. I obtained from Maori sources a story to the effect that, in the time of Te Ao-haere-tahi, who flourished eighteen generations ago, a violent earthquake-shock so lifted these lands that the Awa-a-Taia channel became dry, and Motu-kairangi a part of the mainland. We have no means of verifying such oral traditions, but it may be correct, and the shock may have been the cause of the raised beaches that form so marked and interesting a feature of the adjacent coast-line. The earthquake referred to, if it occurred in the time of Te Ao-haere-tahi, must have occurred in the fifteenth century. There is, of course, abundant evidence showing that the Kilbirnie channel or entrance has existed, and that the sea has flowed over Miramar Flat. At that time the island must have been somewhat in the form of a horseshoe—the Orongo ridge, extending from Point Hippah of D'Urville's chart to the signal-station and onward, curving westward at Puhirangi (near Fort Gordon), and then southward to the Rongotai ridge, at the old Crawford homestead.

Miramar has been occupied by several different tribes, and has served as a refuge for harassed clans from the north, clans fleeing from wrath to come—or, rather, wrath that had come. Thus it was that Ngati-Mamoe, Ngai-Tahu, and Ngati-Ira sojourned in this district. Some of these folk moved across Raukawa (Cook Strait) and settled in the South Island; many of the Ngai-Tara folk did so. Owing perhaps to the fact that there were good fishing-grounds outside the harbour, Miramar and the coast-line on to Owhiro (Happy Valley) were ever favoured places of residence in pre-European times. Te Aro, Thorndon, and the Hutt were places of minor importance as regards Maori occupation. The evidence of this statement was very clear in the earlier days of European

settlement, when the visible signs of old-time Maori occupation were very numerous about Miramar Peninsula; and even now a number of signs are to be seen. There are the remains of a small *pa* on the toe of the spur at Worser Bay, and a number of small terraced hut-sites on the hills. There are the remains of an old *pa* on the hill at Tarakena, just west of Palmer Head, showing small terracings and an eroded earthwork. This was probably the Rangitatau *pa;* but, as already stated, stockades, not earthworks, were the usual defences of local villages, hence it is now often impossible to say whether a formerly occupied place was a *pa* or an open village. The most numerous signs of Maori occupation in this district at the present time are the small linchets, diminutive terraces on hillsides—the hut-sites of neolithic man. Those who have examined such places know that some of them are situated in places that could scarcely have been defended. Similar evidence is given by some of the shell-middens, such as the one at Tarakena (the old pilot-station).

It is disappointing that Cook gives so little information concerning what he saw in this locality. If the Oruaiti *pa*, on Point Dorset, was occupied at that time he must have seen it, and the same may be said of the old fortified villages at Tarakena and on the eastern headland of Lyall Bay. The latter is marked "Point Hippah" on the Barnett chart published with D'Urville's narrative—a pretty good proof that a fortified village was seen there in the "twenties" of last century, either by Barnett in 1826 or by D'Urville in 1827.

The lagoon that formerly existed on the Miramar Flat was in olden times known as Te Roto-kura, but in later days as Pārā. Colonel Wakefield named it Burnham Water. It was drained by the late Mr. Crawford in 1847–49.

Of the various clans that migrated southward to Wellington, the first we have any knowledge of was that known as Ngati-Mamoe. These folk were descendants of the original people of the island, the Mouriuri, of unknown origin, though probably mixed with the later-coming Polynesians. They had long resided in the Hawke's Bay district when pressure from other tribes caused them to move southwards. On reaching this district they seem to have been well received by Ngai-Tara, who gave them the use of lands extending from the coast inland to Karori. They occupied two villages, named Komaru-nui and Makure-rua, at Sinclair Head. Eventually they moved on to the South Island, where a very few of their descendants may still be found.

Another people who came down the east coast of the island was the Ngai-Tahu clan, descendants of Tahu-potiki, who flourished twenty-two generations ago. No satisfactory account of their movements has been collected, but some of them seem to have lived at Miramar. They too crossed to the South Island, conquering and almost exterminating the Ngati-Mamoe.

Yet another people, a portion of the Ngati-Ira tribe of the Waiapu district, marched south and settled on the shores of Palliser Bay. As time rolled on, these Ira folk extended their settlements and occupied the Wellington district, probably by intermarriage with Ngai-Tara, for we know of no fighting between them. These people came down the coast ten generations ago, and in Cook's time the population of the Land of Tara was known by the tribal name of Ngati-Ira.

In the second decade of the nineteenth century troubled times obtained in this district. It was about 1819 that the folk of the Wai-mapihi *pa*, at Pukerua, saw afar off, at Wainui, a long line of men marching southward over the sands of Manaia. Those sons of Ira the Heart-eater knew not

the portent of that dark, straggling, slow-moving column, but of a verity it was the beginning of the end of the *mana Maori* in the land of Tara. For this was no ordinary *taua*, or war-party, armed with spears and stone weapons; it carried the might and cunning of the *pakeha*, the man who deals death from afar, and no man seeth the falling of the blow—they were gun-fighters from the far north.

A mixed force of Ngapuhi, Ngati-Whatua, Ngati-Toa, and others, under Tuwhare, Te Rauparaha, and other leaders, raided the west coast, marched down to Port Nicholson, camped at Pipitea, Te Aro, and the Hutt, and desolated the district. Many of Ngati-Ira were slain; captives were killed daily to provide food for the raiders. The invaders marched on to Wai-rarapa, from which place they returned home. One of the party left us an account of the expedition, in which he says they marched southward a thousand strong, were absent a year, and that the party was five hundred strong when it reached home.

The Ngati-Ira folk had returned to their homes from Wai-rarapa, and forest solitudes to which they had fled, when, in the stirring "twenties," another calamity came upon them. The Ngati-Toa tribe, harassed by enemies, marched south to seek new homes, and with these home-seekers came a number of the Taranaki natives who feared the power of Waikato. They were afterwards joined by many of Ngati-Raukawa. These invaders took possession of the Manawatu, Otaki, and Wellington districts, killing many of the inhabitants, and expelling Ngati-Ira from the Land of Tara. Thus the descendants of Whatonga and Ira were swept from the district, and so ends the story of those old Polynesians, for Ira was a voyager from Tahiti twenty-four generations ago.

The Wellington district was settled by members of the Atiawa tribe of Taranaki, the people who made such a good stand against the Waikato invaders in their *pa* at the Sugarloaves, what time Dicky Barrett and his hard-bitten whalers loaded up their ships' carronades with nails, spikes, iron bolts, and suchlike missiles, and swept lanes through the attacking force. These folk settled at the Hutt, at the mouth of the river; at the Ohiti and Hikoikoi villages; at Pito-one, Nga Uranga, Kaiwharawhara, Te Awa-iti, Pa-kuao, Tiakiwai, Raurimu, Pipitea, Kumu-toto, and elsewhere. Their settlements at Miramar were but small hamlets at Karaka Bay and some other places. When Captain Kent, (known as "Amuketi" to the Maori) visited Port Nicholson, some Maori people appear to have been living at Worser Bay, and a place on Seatoun Flat was named, after him, Te Pou a Amuketi.

The Atiawa tribe was not strong in numbers, and at Wellington they were situated "between the devil and the deep sea." They possessed but indifferent friends in Ngati-Toa at Porirua, while the Wai-rarapa natives were actively hostile. In 1835 Atiawa were weakened by the migration of the Mutunga clan, under Pomare, to the Chatham Islands. At that time some of these Maoris were living on Somes Island, and the "Lord Rodney" was lying there in November, 1835, when the Maori seized her and compelled the captain to convey many of them to the Chathams, where they much enjoyed themselves in slaughtering and eating the unwarlike descendants of refugees who had fled from New Zealand twenty-six generations before.

When Captain Cook anchored near Barrett's Reef on the 2nd November, 1773, the Ngati-Ira folk held the Land of Tara. It is not known who was the next European to visit the harbour; early whalers might have entered it repeatedly without such visits being recorded. Geordie Thoms, the whaler, claimed to have been the first European to enter the harbour,

but nothing is known of the date of such visit. During a hearing of land claims one David Scott, a flax-buyer, stated that he came there in 1831, and lived in a hut about Lambton Quay. George Young, a whaler, claimed to have lived at Thorndon in 1834–35. When Colonel Wakefield arrived in 1839 the European population of this district numbered one—a man named Robinson, who was living with the Maori at the Hutt.

So far as we have any reliable account, the first vessel to enter Port Nicholson was the "Rosanna" (Captain Herd), in the year 1826. This vessel brought out from England about sixty would-be settlers. They seem to have been in search of a location where they could procure flax and spars. The "Rosanna" visited Stewart Island, and then came up the east coast of the South Island and entered Queen Charlotte Sound, after which she came to Port Nicholson. Evidently these places did not attract the would-be settlers and traders, and they sailed again for the north. The boisterous behaviour of the natives of those parts alarmed them, so they declined to settle in New Zealand, and sailed to Australia. While lying in this harbour Captain Herd named it Port Nicholson, after a sea-captain who had become Harbourmaster at Sydney. He also made an excellent chart of the harbour, and this chart shows many lines of soundings, and "Fresh water" appears marked at Nga Uranga, and at the small streamlet at Kilbirnie. For some reason this chart was not published when it would have been extremely useful to the New Zealand Company and others. It came into the possession of the late Mr. A. H. Turnbull, of Wellington, and is in the Alexander Turnbull Library. A copy is reproduced in the 1909 edition of *Murihiku*.

Another excellent chart of the harbour was made by T. Barnett in 1826: this was published, with other maps pertaining to D'Urville's voyages, in 1847, seven years after Captain Chaffers made his chart of the harbour that was published in 1840. This must have been Captain Barnett, of the cutter "Lambton," a craft that accompanied the "Rosanna," though in what capacity I do not know. There are differences in these charts that seem to denote different surveys; though, if the two vessels were here together, why should two tedious surveys of the harbour have been made? It is possible, of course, that the two vessels had separated, and that both entered the harbour at different times. On the Barnett chart Miramar Lagoon is marked "Fresh water," and Somes Island "Isle of the North," both in French. The eastern headland of Lyall Bay is marked "Point Hippah"; so that evidently it was occupied by a native village at that time. The quaint word "*hippah*" was one of Captain Cook's corruptions, and represents the Maori words *he pa*, meaning a fortified village. French longitude is given on this Barnett chart. Apparently D'Urville, who passed through Cook Strait in 1827, seven or eight months after the Barnett chart was made, must have obtained a copy of that chart and inserted French longitude, &c. Among the papers left by the late Dr. McNab is a photograph of (apparently) the original Barnett chart. It is marked "Port Nicholson or Wangenueatera in New Zealand. Surveyed and Drawn by T. Barnett, May, 1826." At the foot of the chart appears the following: "To J. Nicholson, Esq., this Chart is respectfully presented by his most obdt. servt., T. Barnett.—Sydney, March 12th, 1827." Miramar Lagoon is marked "Fresh-water lake," and the word "Hippah" appears as on the D'Urville copy. "Fresh water" is marked at Nga Uranga and Kilbirnie, as on Herd's chart. Owing to differences in soundings, &c., between this and Herd's chart, we must conclude that they were separate surveys; also that D'Urville copied the Barnett chart, reduced the soundings to metres, and inserted French wording.

Some very curious maps of the Wellington district appeared in the first half of last century, and the harbour was shown in many weird forms. Cook's local chart is more correct than McDonnell's map of 1834.

In Sir J. Alexander's *Incidents of the Maori War, New Zealand*, we find a brief note concerning Miramar, as follows: "A sandy peninsula, over which Cook's boats once rowed before an upheaving from earthquakes took place." This myth was commonly believed by young folk of Wellington in my school-days of the "sixties," but no craft has rowed over Kilbirnie Isthmus since the days of the Ngai-Tara.

Tasman marked Cook Strait as a gulf on the coast-line traced by him, and named this country Staten Land. It was named New Zealand when Brouwer, in 1643, proved that the Staten Land to the south of America was not part of a continent, and therefore could not be identified with the Staten Land of Tasman.

One wonders if the Oruaiti *pa*, on Point Dorset, was inhabited when Cook lay off Barrett's Reef. In volume 7 of the *Journal of the Polynesian Society* are recorded some interesting notes concerning that place, and certain occurrences there in olden days. Of the old forts at Kakariki and Tarakena there are no records, nor yet of those on Somes Island. Of the three old *pa* on the Rongotai ridge we know the name of but one, Maupuia, on the southern side of the deep block cut. Butts of some of the old stockade-posts were seen there in former years. It was probably abandoned when Ngati-Ira were expelled from the district in the "twenties" of last century. The Puhirangi *pa* was situated on the ridge near Fort Gordon. I collected a fine *waiata*, or song, connected with this place. It is a lament composed and sung by a woman of a long-past generation for her dead daughter. The picture presented is that of the bereaved mother sitting on the hilltop, looking seaward over the defensive stockades of the village: "Wearily inclines the body, as, within Puhirangi, I look forth on Hine-moana surging restlessly afar off." This Hine-moana is the Ocean Maid, the personified form of the ocean. The mother mourns farewell to the soul of her daughter on its way to the spirit-world, bidding her pass over the vast ocean, back to Irihia, the old homeland of the Maori race, thence to the upper spirit-world, in the uppermost of the twelve heavens, there to be welcomed by the *mareikura*, or celestial maids. The composition is a fine one—a good specimen of the old-time Maori song:—

Pa rawa, e te tahakura
E homai tohu ki au
Kia oho ake e te ngakau.
Ko wai rawa koe e tahu nei i a au
Ka haramai e roto, ka kai 'kohau noa,
Ka waitohu noa.
Tenei tonu i a koe, e te kahurangi
Ko wai rawa ka hua ko koe tonu, e Rangi, e!
Whatatai noa atu e te tinana
I a au ki roto o Puhirangi
E rauwiri noa mai ra a Hine-moana i waho.
Tena ia koe ka riro i te au kume ki Tawhiti-nui
Ki Tawhiti-pamamao, ki Te Hono-i-wairua
I runga o Irihia.
Kia tika to haere ki roto o Hawaiki-rangi
E mau to ringa ki te toi huarewa
I kake ai Tane ki Tikitiki-o-rangi.
Kia urutomo koe ki roto o Te Rauroha
Kia powhiritia mai koe e nga mareikura
O roto o Rangiatea
Ka whakaoti te mahara i kona ki taiao
E hine—e!

The following is a translation:—

> Omens assail me with signs that disturb the mind. Who indeed are you who afflicts me, and causes with vague warning a formless fear and questing mind? It was indeed you, O cherished one! Who would have thought that you would go, O Rangi! Wearily inclines the body as, within Puhirangi, I look forth on Hine-moana surging restlessly afar. But now you have gone, borne on the ocean-stream to far Tawhiti-nui, to Tawhiti-pamamao, to Te Hono-i-wairua on Irihia. Fare on, and carefully enter Hawaiki-rangi. Grasp in your hand the *toi huarewa*, the gyrating way by which Tane ascended to Tikitiki-o-rangi, that you may enter within Te Rauroha, that you may be welcomed by celestial maids within Rangi-atea. Then shall all remembrance of this world cease, O maid!

In how short a time may an ancient race be obliterated! In the Wellington *Independent* of the 22nd August, 1846, appeared the following: "Six large canoes, manned by about sixty natives, entered the harbour yesterday, laden with pigs and potatoes. Twelve more canoes are to follow, the Ngatiawas having crossed the Straits for the purpose of joining their tribe, if required, against the rebels under Rangi-haeata." What would be thought of a fleet of canoes sailing down the Au-a-Tane in the year 1921?

The name of the islet at Island Bay is Tapu-te-ranga, which is also the name of Watchman Isle at Napier. This was the name of a particularly *tapu* place in the old homeland of the race, the lost land of Irihia.

The late Mr. Travers, in 1873, stated that he had seen a family of cave-dwelling Maori living near Seatoun. There were six or seven of them, and they seem to have utilized the cave as a summer residence. This cave is said to be less than a mile from the pilot-station.

Seatoun, it is said, was named after a place in Forfarshire that belonged to the Crawford family. The late Mr. J. C. Crawford changed the name of the peninsula in 1872, dropping the old name of Watt's Peninsula and adopting that of Miramar. Mr. James Watt, after whom it was named, landed some cattle on the peninsula in the early days of the settlement, but is said to have had no further connection with it. In E. J. Wakefield's *Handbook for New Zealand*, published in 1848, we read that two cattle-farms had been established on Watt's Peninsula—one called "Glendavar," at the north end of the lake; the other, Tettcott Farm, among the hills at the south side of the peninsula. The former was established by Mr. J. C. Crawford in 1840, the later by Mr. Francis Molesworth, the farm-house being constructed of stones rolled down from the surrounding hillsides. I believe that a portion of the stone walls is still in existence. The late Mr. James Taylor, of Tawa Flat, lived at Tettcott Farm at one time in the early days.

The remarks of Mr. Crawford on the finding of stumps and logs of forest-trees in the drained bed of Burnham Water seem to show that Miramar Flat has been under forest at some time in the past. Mr. Crawford was of the opinion that, after the disappearance of the forest, the wind scooped out the bed of Burnham Water. This is hardly probable; but sand-drift from the Lyall Bay side probably formed low sand-ridges or bars, and inland of these the waters of spring and storm became confined until a lagoon resulted. These waters destroyed the forest. It was in this way that ancient forests were destroyed north of Pae-kakariki, and the land between sand-ridges converted into water-logged swamps. When the forest on Miramar Flat was destroyed there were too many roots and stumps and too much humus in the soil for it to be affected by wind-action. The statement that forest containing *totara* and *rimu* grew on the Worser Bay face of Seatoun heights is a dubious one. The steep seaward slopes of this vicinity never supported heavy bush. When the early settlers arrived,

Miramar was covered with fern (*Pteris*) mixed with flax and small scrub, such as *koromiko, tutu,* &c. There was a patch of light bush in a gully at the head of Miramar Flat, and a few of the smaller trees at various other places. A number of *karaka* trees along the coast-line would certainly be protected by the Maori. A considerable number of them are still flourishing. Many interesting notes are contained in papers on Miramar Peninsula in volumes 5 and 17 of the *Transactions of the New Zealand Institute.*

We have now seen how Te Whanga-nui-a-Tara, or Port Nicholson, was discovered, explored, settled, and defended. We have seen how courageous neolithic sea-rovers, a thousand years ago, rode down six hundred leagues of rolling sea-roads in their string-tied craft, and opened up the Southern Ocean for all time. We have seen the later-coming adventurers from the far palm-clad isles of eastern Polynesia settle on Motu-kairangi, or Miramar Island, and look down from Te Whetu-kairangi, on the restless waves of Hine-moana and the fair landing of the Turanga-o-Kupe, or Seatoun foreshore. The changing centuries came and went for seven hundred years, until the day dawned when the sons of Tara and Ira saw on the waters of Raukawa the huge canoe of the pale-skinned sea-demons sailing over their ancient sea-roads.

ART. 49—*The Solubility and Hydrolysis of Calcium Carbonate.*

By H. O. ASKEW, M.A.

[*Read before the Philosophical Institute of Canterbury, 6th July, 1921; received by Editor, 31st December, 1921; issued separately, 22nd June, 1923.*]

FROM an examination of the literature of the solubility of calcium carbonate it was found that the effects brought about by the addition of salts to carbonate solutions had been only partially investigated, mostly in comparatively strong solutions, and chiefly in the presence of air. It seemed, therefore, that interesting results might be obtained by examination of the effects produced by very dilute solutions, air being excluded—more especially as certain work carried out by E. A. Rowe (1) tended to show that the effects were uniform—that is, certain types of salts gave similar effects, but each salt had a definite influence, in some cases giving apparent breaks in the solubility-curve. (Private communication.)

The work to be described was carried out for the following purposes: (i) To attempt to verify Rowe's results; (ii) to determine the degree of hydrolysis of calcium carbonate; (iii) to determine, if possible, the effect on the solubility product of calcium carbonate.

The solubility of calcium carbonate has been determined by a number of workers, but the results differ considerably.

Holleman (2) found 1 part of carbonate in 80,040 of water—*i.e.*, approximately 0·0125 gram per litre. He quotes (*l.c.*) the following: Fresenius, 1 part in 16,600 of water; and Bineau, 1 part in 50,000 of water.

Kendall (3) found the value of 0·01433 gram per litre at 25° C.

Gothe (4) found the solubility slightly variable, his final value being 31·0 mg. per litre. This result appears anomalous, but may be explained when the great effects of traces of carbon dioxide, taken up from the air or elsewhere, are considered.

Seyler and Lloyd (5) determined the solubility product of calcium carbonate, obtaining

$$[\mathrm{Ca}^{\cdot\cdot}]\,[\mathrm{CO}''_3] = 71{\cdot}9 \times 10^{-10} \text{ at } 25^\circ \text{ C.};$$

they also obtained the equation

$$\frac{x^2}{1-x} \cdot \mathrm{Ca}^{\cdot\cdot} = 1{\cdot}92 \times 10^{-4}$$

where x is the fraction of carbonate hydrolysed. By solving these equations, the value $14{\cdot}6 \times 10^{-5}$ grm. mols. per litre is obtained. This result agrees closely with that of Kendall.

McCoy and Smith (6) calculated from the data of Kohlrausch (7) for the conductivity of saturated solutions of calcium carbonate a solubility of 12 mg. per litre. Their calculation allowed for hydrolysis to the extent of 66 per cent. They themselves obtained the value 16·6 mg. per litre. They say no explanation of the discrepancy is forthcoming.

An important matter in relation to all these determinations is the partial pressure of the carbon dioxide in contact with the solution. For each pressure there is a definite concentration of ions derivable from calcium carbonate. For a discussion of this point see especially a paper by Johnston and Williamson (8).

In the presence of salts of the alkalis the solubility of calcium carbonate is greatly altered, perhaps by formation of complex ions, thus reducing the concentration of the calcium ions.

Gothe (*l.c.*) states that the solubility is increased by chlorides, nitrates, and sulphates; while a decrease occurs in the presence of alkali carbonates and salts of the alkaline earths.

Rowe (*l.c.*) came to somewhat the same conclusions, and added, "as regards the alkalis, that calcium carbonate appears most soluble in the ammonium salt of any given acid, and in solutions of the sulphate of any given base." He also found that there is apparently a discontinuity in the curve with solutions of sodium chloride of strengths about M/500. (Private communication.)

In this present case the apparent solubility of calcium carbonate, in the calcite form, was determined in gas-free water, in presence of varying amounts of alkali salts; while the degree of hydrolysis was deduced from electromotive-force measurements.

Solubility Measurements.

These were carried out in Jena glass vessels fitted with mercury-sealed stirrers and side tubes leading to a series of guard-bottles. This form was adopted after two other types of solution-vessels had been used. A multiple apparatus was set up. A large rectangular copper bath was used as a thermostat, the sides being protected with asbestos and wood. A large toluol regulator was used to maintain the temperature at 25·0° C.; while a spiral tube stirrer driven by a hot-air engine was employed to keep the

water in circulation. The solution-vessels with their stirrers were supported in the bath. The pulleys from the stirrers were connected by means of solid rubber belting with a central pulley, which in turn connected with a small electric motor. It was thus possible to remove any one or more of the vessels without causing a stoppage of the motor.

In the solution-vessel were placed 3·000 grams of finely powdered calcite crystals and 250 c.c. of salt solution (freshly made from gas-free water). The contents were kept stirred at a rate sufficiently high to keep the carbonate in suspension. The solutions were left for several days, the period depending on the concentration of the salt solution; the period was determined by a series of experiments, sodium chloride being taken as standard. The calcium in solution was estimated as oxide or sulphate.

The effect of traces of carbon dioxide is very considerable, since ordinary distilled water gave a much larger value than the freshly boiled water: for example—

Ordinary distilled water ..	$19{\cdot}6 \times 10^{-5}$ grm. mols. per litre.
Gas-free water	$13{\cdot}4 \times 10^{-5}$ grm. mols. per litre.

and also with sodium-chloride solutions. The figures are—Gram molecules of carbonate per litre $\times 10^5$.

Concentration of NaCl	$\frac{M}{50}$	$\frac{M}{100}$	$\frac{M}{150}$	$\frac{M}{200}$	$\frac{M}{400}$	$\frac{M}{500}$	$\frac{M}{600}$	$\frac{M}{800}$	$\frac{M}{1000}$
Ordinary distilled water	69·8	35·9	32·1	28·4	22·2	19·1	16·5	16·1	16·3
Gas-free water	52·0	28·6	25·0	24·1	17·9	17·9	17·9	16·1	16·1

From this it appears that a slight minimum occurs in presence of traces of carbon dioxide at about M/800; but this disappears from the second set.

The following table summarizes the results of the solubility measurements (gram molecules of carbonate $\times 10^5$):—

Salt ..	$\frac{M}{50}$	$\frac{M}{100}$	$\frac{M}{150}$	$\frac{M}{200}$	$\frac{M}{400}$	$\frac{M}{500}$	$\frac{M}{600}$	$\frac{M}{800}$	$\frac{M}{1000}$
NaCl ..	52·0	28·6	25·0	24·1	17·9	17·9	17·9	16·1	16·1
NaBr ..	40·9	25·0	23·4	20·5	17·1	16·1	15·2	12·5	11·6
$NaClO_3$ ..	63·4	32·0	27·7	25·0	16·1	16·1	16·1	17·9	17·0
$NaNO_3$ ..	67·8	34·5	30·4	28·6	19·3	17·9	17·9	16·1	16·1
KCl ..	32·0	26·8	25·0	24·1	17·0	..	15·0	..	14·3
KBr ..	41·7	24·1	..	21·4	..	..	16·1	..	15·2

From these figures it is seen that a similar type of curve is obtained in each case, but the effect is not proportional to the concentration of the salt solution. Sodium chlorate and nitrate give very large increases.

MEASUREMENT OF HYDROLYSIS.

The velocity-constant method for the determination hydroxyl ions was not successful in this case, so recourse was had to electromotive-force measurements.

By measurement of the electromotive force developed in a cell one element of which contains the solution under consideration, the concentration of the hydroxyl ions may be obtained. The actual determination is that of the hydrogen-ion concentration, but the hydroxyl-ion concentration is then given by the relation

$$[H^{\cdot}]\,[OH'] = 1 \times 10^{-14} \text{ at } 25^{\circ}\text{ C.}$$

The formula used for the calculation of the hydrogen-ion concentration is

$$E = E_0 + 0{\cdot}059 \log_{10}C \text{ at } 25° \text{ C},$$

where E = E.M.F. of the element in volts, E_0 = 0·277 volt, C = concentration of hydrogen ions.

When a normal calomel electrode is used as the other half-element, if x is the observed E.M.F., then the potential of the other element is

$$(0{\cdot}564 - x) \text{ volt at } 25° \text{ C.},$$

which is E of the formula above.

Also, according to theory, the observed E.M.F. will increase with decrease of hydrogen-ion concentration; and, since the carbonate solutions are all akaline to phenolphthalein, the hydrogen-ion concentration will be small, and hence the observed E.M.F. will be great.

This difference of potential may be deduced approximately as follows: The concentration of the calcium ions in the solution is of the order 10^{-4} grm. mols. per litre. Now, assuming that the calcium exists solely as carbonate or the products of hydrolysis of the carbonate, the hydrogen ion is present at about 10^{-10} grm. mols. per litre.

Since the hydrolysis of the carbonate proceeds according to the equation

$$2CaCO_3 + 2H_2O = Ca(OH)_2 + Ca(HCO_3)_2$$

it follows that, knowing the concentration of the calcium, and assuming that all exists in the ionic form, the greatest possible concentration of hydroxyl ions is determined. Then, knowing the hydrogen-ion concentration, the degree of hydrolysis of the carbonate may be deduced at once; and from the hydroxyl-ion concentration the concentration of the carbonate ion is determined, from the relation found by Seyler and Lloyd (5):—

$$\frac{(OH)^2}{(CO_3'')} = 1{\cdot}92 \times 10^{-4},$$

whence the value of the product $[Ca^{\cdot\cdot}][CO_3'']$ may be calculated.

The E.M.F. produced was measured by the ordinary potentiometer method. The usual wire was replaced by a pair of resistance-boxes and a high-resistance galvanometer employed as zero instrument. A cadmium cell was used as standard. Two types of hydrogen electrode were used—(i) Luther-Brislee, and (ii) platinized wire sealed into glass tubing, as recommended by C. J. J. Fox (9). Both electrodes gave identical results.

The hydrogen used was prepared by electrolysis, the gas being passed through a hot tube containing platinized asbestos to remove the traces of oxygen. The hydrogen was generated under a pressure sufficient to keep the gas bubbling through the solution. The solutions were filtered through cotton-wool out of contact with air, the first portions being rejected. The electrode vessel was then left in the thermostat till the liquid was saturated with hydrogen.

In some cases a maximum E.M.F. was found; the observed E.M.F. in no case reached the theoretical, the defect being some hundredths of a volt. It appeared that some unknown factor was at work. Nevertheless, the data obtained yielded some useful information: this will be considered in the general discussion.

Discussion of Results.

The solubility-curves obtained were not straight lines, and the deviation was greater than the experimental error. Apparently a new effect appears at about M/50, since a sudden change of direction occurs near this point.

The apparatus was airtight, and the pressure of the carbon dioxide under these conditions may be considered about $3{\cdot}7 \times 10^{-7}$ atmosphere. (Johnston and Williamson (8).)

Johnston and Williamson obtained a minimum concentration of calcium carbonate at this pressure, their value being 16×10^{-5} grm. mols. per litre at 16° C. On either side of this value the concentration increased rapidly, thus again showing the great influence of the carbon dioxide. For this minimum concentration they found that the hydrolysis was about 54 per cent. Against this value is that of Seyler and Lloyd (5)—namely, 66·7 per cent.

In discussing the electromotive-force experiments it was shown that theoretically, and in part practically, the concentration of the hydroxyl ion in the solution can be determined.

Now, the ions present in the solution are

$$H^{\cdot},\ Ca^{\cdot\cdot},\ HCO_3',\ OH',\ \text{and}\ CO_3'',$$

if the presence of the neutral salts be neglected. And between these ions the following relations exist:—

$$Ca^{\cdot\cdot} = CO_3'' + \frac{HCO_3'}{2} + \frac{OH'}{2}$$

$$H^{\cdot} \times OH' = 1 \times 10^{-14}$$

$$\frac{H^{\cdot} \times CO_3''}{HCO_3'} = 4{\cdot}15 \times 10^{-11}$$

The last equation is due to Kendall (10).

Hence if y is the concentration of the calcium ion and c that of the hydrogen ion, then

$$y = y\,(1 - x) + \frac{1 \times 10^{-14}}{2c} + \frac{Cy\,(1 - x)}{2 \times 4{\cdot}15 \times 10^{-11}}$$

where x is the degree of hydrolysis of the carbonate.

This more complicated relation takes the place of that deducible approximately, viz.,

$$x = 1 = \frac{1 \times 10^{-14}}{Cy}$$

The following table contains some of the more reliable data:—

Salt.	Concentration of Salt.	$Ca^{\cdot\cdot} \times 10^4$.	$H^{\cdot} \times 10^{10}$.	$OH' \times 10^5$.	Per Cent. Hydrolysis.
NaCl ..	M/400	1·98	4·1	2·44	84
NaCl ..	M/500	1·62	2·3	4·35	79
NaCl ..	M/1000	1·44	1·95	5·00	75
$NaNO_3$ ..	M/100	3·00	4·7	2·1	83

Owing to the extremely high resistance of the pure-water solutions, reliable values could not be obtained.

For the purpose of the above calculations the degree of ionization of the carbonate was taken as 0·9.

From the above table the product $[Ca^{\cdot\cdot}]\,[CO_3'']$ may be calculated. Values are obtained ranging from 52 to 64×10^{-10}, and in a few cases as low as 26×10^{-10}, using Seyler and Lloyd's equation, $[Ca^{\cdot\cdot}]^2\,(1 - x)$ = constant.

By considering the effect of the neutral salts in the solutions the following equation is obtained :—

$$x^2 (1 - 4b - 4a) + x (b^2 + 4ab) - ab^2 = 0.$$

a = total concentration of calcium ions ; b = original concentration of alkali salt ; x = concentration of alkali carbonate formed.

From this equation the following results may be deduced :—

(i.) The concentration of calcium as carbonate in the solution is nearly constant, being that of the carbonate in pure water.

(ii.) The concentration of alkali carbonate is proportional to the concentration of the added salt.

(iii.) The value of the ratio $\frac{CaCO_3}{M_2CO_3}$, where M_2CO_3 is the alkali carbonate, for a given dilution is independent of the salt used. The values for a series of dilutions lie on a straight line in each case.

As an example, some of the results obtained with sodium bromide may be quoted :—

Concentration.	$CaCO_3 \times 10^5$.	$Na_2CO_3 \times 10^5$.	$\frac{CaCO_3}{Na_2CO_3}$.
M/50	15·7	24·5	0·6
M/100	13·5	12·4	1·1
M/200	14·7	5·8	2·5
M/400	14·2	2·9	4·9
M/500	13·8	2·3	6·0
M/1000	11·5	1·05	11·0

The following conclusions were drawn from the work done :—

1. The solubility of calcium carbonate (calcite form) in gas-free water at 25° C. in a closed vessel is $13{\cdot}4 \times 10^{-5}$ grm. mols. per litre. The mean value in ordinary distilled water is $19{\cdot}6 \times 10^{-5}$ grm. mols. per litre.

2. The presence of traces of carbon dioxide exerts a considerable influence on the solubility.

3. The degree of hydrolysis of calcium carbonate may be calculated by electrometric means. Similarly, the value of the solubility product may be calculated.

4. The addition of known quantities of neutral salts increases the solubility, but not regularly.

5. It is doubtful if there exists a minimum concentration of the carbonate in presence of sodium chloride except in presence of small quantities of carbon dioxide.

Literature cited.

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(2.) A. F. Holleman, *Zeit. physik. Chem.*, vol. 12, p. 135, 1893.
(3.) J. Kendall, *Phil. Mag.* (vi), vol. 23, pp. 958–76, 1921.
(4.) F. Gothe, *Chem. Zeit.*, vol. 39, pp. 305–7, 1915.
(5.) C. A. Seyler and P. V. Lloyd, *J.C.S., Trans.*, vol. 111, p. 996, 1917.
(6.) H. N. McCoy and H. J. Smith, *J. Am. C.S.*, vol. 33, p. 473, 1911.
(7.) F. Kohlrausch, *Zeit. physik. Chem.*, vol. 54, p. 236, 1903.
(8.) J. Johnston and D. Williamson, *J. Am. C.S.*, vol. 38, p. 975 *et seq.*, 1916.
(9.) C. J. J. Fox, *B. A. Rep.*, p. 457, 1909.
(10.) J. Kendall, *J. Am. C.S.*, vol. 38, p. 1480, 1916.

PROCEEDINGS.

PROCEEDINGS

OF THE

NEW ZEALAND INSTITUTE.

MINUTES OF THE ANNUAL MEETING OF THE BOARD OF GOVERNORS.

WELLINGTON, 31ST JANUARY, 1922.

THE annual meeting of the Board was held in the Dominion Museum Library on Tuesday, 31st January, 1922, at 10 a.m.

Present: Professor T. H. Easterfield (President, in the chair), Mr. B. C. Aston (Hon. Secretary), Professor C. Chilton, Dr. L. Cockayne (representing the Government), Professor C. A. Cotton (representing the Wellington Philosophical Society), Mr. M. A. Eliott (Hon. Treasurer, Manawatu Philosophical Society), Professor C. C. Farr (Philosophical Institute of Canterbury), Mr. W. G. Howes (Otago Institute), Mr. T. Hyde (Hawke's Bay Philosophical Society), Professor P. Marshall (Wanganui Philosophical Society), Professor E. Marsden (Wellington Philosophical Society), Professor H. W. Segar (Auckland Institute), Dr. R. J. Tillyard (Nelson Institute), Hon. Mr. G. M. Thomson (Otago Institute), Mr. A. M. Wright (Philosophical Institute of Canterbury), Professor F. P. Worley (Auckland Institute). Professor H. B. Kirk was present by request of the Standing Committee.

Apologies for non-attendance were received from the Hon. W. Downie Stewart (Minister of Internal Affairs), Dr. J. Allan Thomson (Government representative), and the Ven. Archdeacon Williams (representing the Poverty Bay Institute).

Roll-call.—The Hon. Secretary then called the roll.

Presidential Address.—The President then read his presidential address.

Resolution of Sympathy.—The President then called upon Professor Farr, who moved the following resolution: "That this Board learns with the greatest sorrow of the death of Sir Ernest Shackleton, and desires to place on record its admiration for his unbounded determination, great bravery, and heroic devotion to his comrades—qualities which have gone far to making the best traditions of our race. The Board also recognizes the great contribution of Sir Ernest Shackleton to our knowledge of the South Polar regions, and expresses its deepest sympathy with Lady Shackleton in her sudden bereavement." The motion was seconded by the Hon. Mr. G. M. Thomson, and carried in silence, the members standing.

Mr. S. Percy Smith.—On the motion of the Hon. Mr. G. M. Thomson, seconded by the President, a message of sympathy with Mr. Percy Smith, F.N.Z.Inst., of New Plymouth, in the serious illness from which he is suffering, was passed.

Incorporated Societies' Reports.—The reports of all the societies except that of Poverty Bay were laid on the table. On the motion of the President, seconded by the Hon. Mr. G. M. Thomson, it was resolved to refer the reports and balance-sheets of these societies to the Hon. Treasurer for his report on them.

Standing Committee's Annual Report.—The report of the Standing Committee was then considered clause by clause, and adopted with two slight additions.

STANDING COMMITTEE'S REPORT FOR THE YEAR ENDING 31ST DECEMBER, 1921.

Meetings.—Ten meetings of the Standing Committee were held during the year, the attendance being as follows: Professor Easterfield (President), 9; Professor Kirk, 9; Dr. Cockayne, 5; Hon. G. M. Thomson, 4: Dr. J. A. Thomson, 2; Professor Segar, 1; Professor Thomas, 1; Mr. M. A. Eliott, 1; and Mr. B. C. Aston (Hon. Secretary), 10.

Hector Award.—The award for 1920 was made to Mr. R. Speight, Christchurch, for his valuable work in petrology, physiography, and stratigraphy, which had been carried on with zeal and energy since 1892. A special meeting of the Philosophical Institute of Canterbury was held on the 26th July, when the Hector Medal was presented to Mr. Speight by Professor Easterfield, President of the New Zealand Institute.

Transactions of the New Zealand Institute, Volume 53.—This volume was issued to the incorporated societies in bulk in September and October, 1921, and to the exchanges on the 5th December. Copies of the volume were laid on the tables of the Legislative Council and the House of Representatives on the 29th and 27th September respectively.

Publications.—The following have been placed on the mailing-list by the Standing Committee, and will in future receive the *Transactions* as published:—

Imperial Bureau of Entomology, London.
Biologisches Zentralblatt, Berlin-Dahlem.
Universitets biblioteket, Uppsala.
The Academy, Abo, Finland.

Annual Reports and Balance-sheets.—The annual reports and balance sheets of the incorporated societies have been received as follows, and it is intended to submit them to the Hon. Treasurer to aid him in advising the Standing Committee on financial questions:—

Auckland Institute, for year ending February, 1921.
Philosophical Institute of Canterbury, for year ending 31st October, 1921.
Manawatu Philosophical Society, for year ending 23rd November, 1921.
Nelson Institute, for year ending 31st December, 1921.
Hawke's Bay Philosophical Institute, for year ending 31st December, 1920.
Wellington Philosophical Society, for year ending 30th September, 1921.
Wanganui Philosophical Society, for year ending October, 1921.
Otago Institute, for year ending 30th November, 1921.

Fellowship of the New Zealand Institute.—On the 23rd June the appointment of Dr. Cotton, Dr. Hilgendorf, Rev. Dr. Holloway, and Professor Park to the Fellowship of the New Zealand Institute was gazetted, and copy of the *Gazette* notice was forwarded to each of these gentlemen.

At last annual meeting a committee consisting of Professors Segar, Sommerville, Easterfield, and Dr. Thomson was set up to draw up rules for a simple method of voting. This committee decided to send out a voting-paper containing the names of the nominees for the Fellowship, and asking voters to place a cross against the names of the candidates for whom they wished to vote. Societies were circularized on the 4th May and asked to forward nominations for the Fellowship for 1922; they were informed that the consent of every candidate must be obtained in writing and that the information supplied concerning the qualifications of each candidate must be capable of being reproduced as a single foolscap sheet of typewritten matter. The information to be given in the following order:—

(1.) Name of candidate.
(2.) Degrees, membership of societies, position now held, positions formerly held.
(3.) Statement of approximate number of books and original scientific papers published, together with the names of the journals in which the latter appeared.
(4.) Statement of the titles of not more than six of the most important papers.

The societies sent in twenty-two nominations, which were submitted on the 4th July to the Fellows of the Institute for selection. On the 14th September the Hon. Returning Officer, Professor Segar, forwarded the results of the selection, and these were communicated to every Governor on the 16th September.

Publications.—A partial set of *Transactions* issued during the war was supplied to the Naturforschende Gesellschaft, Bern, and the numbers issued during the war were supplied to a number of institutions in Germany and other late enemy countries who wrote in reply to the Institute's inquiry asking that they be reinstated on the exchange list.

Index, Volumes 41–51.—This index was printed and issued on the 14th July, 1921, and the Standing Committee decided that the price should be 2s., and that no free or complimentary copies be issued.

Science Congress Resolutions.—On the 7th February it was resolved that a copy of the resolutions of the Palmerston North Science Congress be forwarded to such Ministers as they concern and to the Minister of Internal Affairs, and that the covering letter should explain that they have been received from the Secretary of the Science Congress, with a request that the resolutions should be forwarded to the Government.

Fireblight.—On the 11th February the Government Statistician wrote stating that it appeared quite impracticable to him to take, in conjunction with the population census, "an absolutely complete census of all hawthorn hedges or single plants and all other hosts of fireblight." On the 3rd March the Hon. Minister of Agriculture wrote acknowledging receipt of two resolutions of the Science Congress regarding fireblight (*Bacillus amylovorus*), and stated that the matter was under active consideration by himself and his officers, and that due weight would be given to the opinion of the Congress as conveyed in the resolutions.

Seismology.—On the 1st June the Hon. Minister of Internal Affairs wrote that, in regard to seismological equipment, the question of adding to the equipment now on order a seismograph registering vertical movement will be given due consideration when the present financial stringency is over.

Yale Telescope.—In respect to the Yale offers, as it was found that the actual specifications and the size of the small photographic telescope had not been furnished by Dr. Schlessinger he has been requested kindly to supply this information together with working-drawings, when it will be seen whether the mountings offered by the Wanganui Astronomical Society, the Wellington Philosophical Society, and the Seminary of Greenmeadows, Napier, will be suitable. A decision will then be arrived at by the Government as to the acceptance or otherwise of such offer. In regard to the offer of the telescope for stellar observations, the Government cannot see its way at present to give effect to the proposals of the Yale observatory, but if the money could be raised by private subscription it considers the project is one which should be carried out.

Longitude Standardization.—With reference to the standardization of longitudes, the erection of a high-powered wireless receiving outfit at the Observatory having been recently authorized, and the question of finding a permanent situation for the Observatory being under consideration, the Government, while in sympathy with the Empire scheme, is not at present prepared to incur any further expenditure in the provision of the additional equipment, staff, and housing required for the carrying-out of this work.

International Catalogue of Scientific Literature.—On the 23rd February Dr. Thomson, Hon. Librarian, reported that for the purposes of carrying on the *International Catalogue of Scientific Literature* the Royal Society required from New Zealand a contribution of a capital sum of £425 and an annual contribution of £213, otherwise the *Catalogue* would lapse. The Standing Committee referred the matter to the incorporated societies, and at a meeting held on the 9th March the Standing Committee resolved that the *Catalogue* authorities be informed that, although the *Catalogue* has been found to be of service by certain biologists in New Zealand, the Standing Committee, in view of the financial stringency, considers it hopeless to get a guarantee for such a large amount as that asked for from New Zealand. This resolution was communicated to the Royal Society on the 21st July, and a reply was received stating that as it was found that the total promises received in respect of income amounted to less than one-third of the eighty units, the minimum with which the Royal Society was prepared to resume the administration of the *Catalogue*, while in respect of working capital the proportion was even smaller, the President and Council had no choice but to decline, with the

greatest regret, the invitation of the Conference of September, 1920, to resume the administration of the *Catalogue*. On the 17th October Professor Dendy wrote, enclosing a letter from the Director of the *International Catalogue of Scientific Literature*, intimating that the winding-up of the *Catalogue* was inevitable, and asking the opinion of the Institute as to whether any purpose would be served in calling a meeting of the International Council. The Standing Committee replied in the negative, and gave Professor Dendy power to act in the matter.

Hamilton Prize.—In accordance with a resolution of last annual meeting, a letter, dated 31st January, was sent by the President to the Wellington Philosophical Society asking that arrangements be made to hand over the balance of the fund to the Institute, so that it might be invested with the Public Trustee, and the various societies might be informed, thus facilitating the making of the first award in January, 1922. No reply was received from the society; and the President again wrote on the 24th May laying before the society the facts in connection with the offer of the society to hand over the funds, and stating that at the annual meeting of the Board of Governors held in 1921 it was understood that, as the society had not expressed any disagreement with the proposed rules and regulations as drawn up by Mr. Von Haast at the request of the Standing Committee, they were in favour of them. On the 7th June the Wellington Philosophical Society wrote asking that certain alterations should be made in the conditions. As the Standing Committee had no power to agree to the alterations, the letter and the matter of the Hamilton Memorial Prize Fund were referred to the annual meeting in 1922. (See *Trans. N.Z. Inst.*, vol. 53, p. 494, and vol. 50, p. 333.)

Samoan Observatory Committee.—On the 8th March Professor Marsden, who had recently spent three months in Samoa, wrote to the President intimating that Cabinet had decided to close down the Samoan Observatory, and urging the Institute to use its influence to prevent this step being taken. On the 9th March the President wrote to the Hon. Minister of External Affairs and placed before him the following resolutions:—

(1.) "That, in view of the difficulty found by Cabinet in financing a complete scheme for a Samoan Observatory, and the ridicule which will fall to the lot of New Zealand in the event of the permanent closing of the Observatory, a request be made to Cabinet, through the Hon. Minister of External Affairs, asking that a smaller scheme be adopted, at a cost not exceeding £1,250 per annum, to keep in existence the most essential activities—namely, seismological and magnetical observations."

(2.) "That the apparatus not required under the smaller scheme be carefully stored with a view to recommencing activities so soon as the financial stringency due to the fallen values of Samoan products disappears."

This letter was acknowledged by the Hon. Minister, who stated that he would be glad to place the representations of the Institute before the Government for its consideration. On the 6th September the Hon. Minister again wrote, stating that, as it had now been decided to continue the Samoan Observatory, he proposed to set up an honorary Board of Scientific Advice, consisting of the Naval Adviser, Government Astronomer, Government Meteorologist, the Surveyor-General, the Secretary of External Affairs, and four nominees of the New Zealand Institute, to advise his Department on the programme of work and other matters affecting the institution. At a meeting of the Standing Committee held on the 22nd September the following gentlemen were appointed to represent the Institute: Professors C. C. Farr, E. Marsden, D. M. Y. Sommerville, and Dr. P. Marshall.

Australasian Association for the Advancement of Science.—The invitation by the New Zealand Institute to the Australasian Association for the Advancement of Science to meet in Wellington in 1923 has been accepted. The organization of the meeting is to be left in the hands of a committee originally set up by the Wellington Philosophical Society, together with others which the committee might add to its numbers, that committee having been recognized by the Australasian Association for the Advancement of Science.

Carter Bequest Committee.—At a meeting of the Standing Committee held on the 25th July the Government Astronomer (Dr. Adams), representing the Wellington Philosophical Society, attended and suggested that by the aid of a committee the funds of the Carter Bequest might be augmented and the objects for which the funds were bequeathed more quickly attained. The Standing Committee resolved to set up a committee, the duties of which should be to report on the effective utilization of the funds of the Carter Bequest, and that the Standing Committee request the New Zealand Government, the Victoria College Council, and the Council of the Wellington Philosophical Society each to nominate a representative to act upon the Carter Bequest Committee in reporting upon the possible scheme or schemes which might be adopted. Professors Kirk and Marsden were appointed to represent the Institute; and, at the

request of the Wellington Philosophical Society, the Standing Committee at its meeting on the 22nd September decided to enlarge the committee by asking the City Council to nominate a representative. The Carter Bequest committee is now as follows:—

Representing the Government: Dr. C. E. Adams.
Representing the New Zealand Institute: Professors Kirk and Marsden.
Representing the Victoria College Council: Mr. P. Levi.
Representing the Wellington Philosophical Society: Mr. A. C. Gifford.
Representing the City Council: Mr. T. Forsyth.

On the 9th December Professor Kirk reported that meetings of this committee had been held, and a report would be submitted in due course.

The majority and minority reports, duly received, follow:—

Majority Report (signed by all members of the committee but one).

"The President of the New Zealand Institute, Nelson.

"Sir,—

"The committee consists of the following members: Dr. C. E. Adams, Government representative; Professor Kirk and Professor Marsden, representing the New Zealand Institute; Councillor Forsyth, representing the Wellington City Council; Mr. P. Levi, representing the Council of the Victoria University College; Mr. A. C. Gifford, representing the Wellington Philosophical Society.

"The committee, by a substantial majority, makes the following report and recommendations:—

"The Carter Fund amounts to a little under £5,000, having grown by accumulation of interest from an amount of a little over £2,000, which represented the residue of Mr. Carter's estate. The object of the bequest, as stated in the will, is 'to form the nucleus of a fund for the erection in or near Wellington aforesaid, and the endowment of a professor and staff, of an astronomic observatory, fitted with telescope and other suitable instruments for the public use and benefit of the colony, and in the hope that such fund may be augmented by gifts from private donors, and that the observatory may be subsidized by the Colonial Government.' The testator indicated his wish that 'the telescope may be obtained from the factory of Sir H. Grubb, in Dublin, Ireland.'

"The bequest has not proved the nucleus of a fund: it, with its accumulated interest, is still the sole fund. It is probable that this is due to the fact that there is no general knowledge as to the existence of the fund. If there were an observatory to which the public could be invited, a Carter Observatory, that would in itself be a means of letting the public know the facts of the case, and it is more than likely that substantial donations would be received. The committee therefore recommends that a portion of the Carter Fund be made available for the erection, in the Botanical Gardens, of a Carter Observatory, in which the King telescope (manufactured by Sir H. Grubb) shall be installed, the observatory to include a lecture-hall. The experience of the Astronomical Section of the Wellington Philosophical Society shows that this would lead to an immediate accession of public interest, and it would enable very valuable educational work to be done. At the same time, it would greatly extend the present scanty facilities for research. On behalf of the Astronomical Section of the Wellington Philosophical Society, Mr. Gifford has lent the committee the accompanying plan of the proposed buildings, the plan having been prepared by Mr. Page. A well-known firm of builders is prepared to sign a contract for the erection of this building for £1,950, not including external drainage and disposal of spoil. The committee recommends that a sum approximately of £2,000 be made available from the Carter Fund for this purpose.

"In order to save the time of the Institute in case it decides to act on this recommendation, the committee approached the City Council, through Councillor Forsyth. On his motion the City Council decided to seek from Parliament this session power to give the Institute a secure tenure of a site, not exceeding a quarter of an acre, in the Botanical Gardens. The experience of the Astronomical Section of the Wellington Philosophical Society shows that there would be a sufficient income from donations and from payments for admission to lectures, &c., to cover the working-expenses of the proposed observatory; and there is very good reason to believe that the public interest would be so stimulated that the remainder of the fund would become the 'nucleus' that the testator contemplated.

"It is asked that the plan may be returned to Mr. Gifford.

"C. E. Adams. P. Levi.
"Thos. Forsyth. E. Marsden.
"A. C. Gifford.

"Wellington, 6th January, 1922."

Minority Report.

"The President of the New Zealand Institute, Nelson.

"SIR,—

"While I regard the proposals of the committee as outlining a scheme of decided educational value, I am yet compelled to dissent from the view that the scheme proposed is one that ought to be financed from the Carter Fund. The testator referred to his bequest as the nucleus of a fund for the establishment of an astronomic observatory to be fitted with a telescope and other suitable instruments, and for the endowment of a professor and staff. It seems to me that he contemplated, especially in the matter of the telescope, something very much in advance of the present proposal, a telescope very much bigger than the King telescope. There were at the time of the will other telescopes in the colony as powerful as this, or more powerful, and it is not likely that a special bequest would have been made for a telescope that was not to be the best, at least in Wellington. Mr. King himself was entirely of this opinion with regard to the Carter bequest, and on the council of the Wellington Philosophical Society strongly opposed any attempt to utilize the fund until it should be great enough to carry out the wishes of the testator. It is urged that we ought not to have an amount of close on £5,000 lying idle. It is my opinion that we have little choice—that we are under a moral obligation to let the fund grow until a worthy memorial can be provided from it. It would be more fitting to provide in several years' time a memorial of some grandeur, and one of which the Dominion would have cause to be proud, than to provide at once a memorial on a very much smaller scale, even though the former course would involve that our successors, and not we ourselves, should derive benefit from it.

"H. B. KIRK.

"Wellington, 6th January, 1922."

Reinvestment of Trust Funds.—On the 7th February a proposal by the Hon. Secretary came before the Standing Committee to transfer its trust funds—namely, the Carter Bequest, the Hector Memorial Fund, and the Hutton Memorial Fund—then in the hands of the Public Trustee into Government war bonds or other investment where the interest was considerably higher. On the 12th February the Hon. Treasurer reported in favour of reinvesting the funds in Government inscribed stock at 5½ per cent. At a meeting of the Standing Committee held on the 12th March the following resolution was passed: "That the Hector, Hutton, and Carter Trust Funds be reinvested after the 31st March, 1921, in Government inscribed stock bearing interest at 5½ per cent." It was also resolved "That the Public Trustee be given notice of the intention to withdraw the whole amounts as soon as possible if the above resolution is confirmed by a general meeting of the Board"; and "Details of the purchase of stock to be left in the hands of the Hon. Treasurer and Hon. Secretary."

A favourable opinion was received on the 11th May from Messrs. Chapman, Skerrett, Tripp, and Blair, who had been approached as to the power of the Board to reinvest the funds, and an extraordinary general meeting of the Board of Governors was called for the 8th June, when the following resolution was passed: "It is hereby resolved by the Board of Governors of the New Zealand Institute that the fund known as the Carter Bequest, consisting of the principal originally placed by the Board of Governors in the hands of the Public Trustee together with the interest accrued thereon, shall now be withdrawn from the Public Trustee and reinvested in such securities as provided for by legislation covering trust-moneys, power to arrange details and to act to be given to the Hon. Secretary and the Hon. Treasurer acting conjointly." Similar resolutions concerning the Hutton Memorial Fund and the Hector Memorial Fund were passed. On the 9th June a deputation consisting of Professor Easterfield, Dr. Cockayne, Mr. Aston, and Mr. Von Haast waited upon the Public Trustee, who promised that the principal of the three funds—the Carter Bequest, the Hutton and the Hector Memorial Funds—together with the accrued interest thereon, would be paid over to the Hon. Treasurer of the New Zealand Institute on the 1st July, 1921. On the 27th June the Hon. Secretary reported the purchase of inscribed stock, bearing interest at 5½ per cent., at 91½, in amount large enough to absorb all the capital and accrued interest of the three funds, forward delivery to be made on the 1st July, 1921. On the same date it was resolved that separate accounts be opened in the Post Office Savings-bank for the Carter Bequest, the Hector Memorial, and the Hutton Memorial, and that Mr. M. A. Eliott and Mr. B. C. Aston be appointed trustees of these three funds. On the 25th July the Hon. Secretary reported that the investment of the three funds had been completed, and it was resolved to deposit the certificates of titles with the Bank of New Zealand for safety.

Library Housing.—On the 11th May the matter of the congested state of the library was brought up, and it was resolved that, the question of the possible danger

to the Dominion Museum building due to the weight of books stored in the library having been raised, the Acting Director of the Dominion Museum be communicated with and asked to obtain a report as to the advisability of erecting further shelving. The Acting Director reported that the Public Works Department had the matter in hand. A letter, dated 1st September, from the Philosophical Institute of Canterbury with reference to the recent fire in the Museum and the danger to the library was read, and, after discussion, and a letter from the Department of Internal Affairs having been read, it was resolved that Professor Kirk, Hon. Mr. G. M. Thomson, Dr. Cotton, and Mr. Johannes Andersen be a committee to inquire into the most suitable place to house the library of the New Zealand Institute temporarily, Professor Kirk to be convener of the committee. On the 9th December a report was received from Professor Kirk regarding the housing of the library, and asking for an expression of opinion from the Standing Committee in order that certain provisions might be made to allow alterations at a lower cost than would be possible later in the Victoria College building in the event of the full Board of Governors being willing to transfer the library to that building. It was resolved that, owing to the state of the finances, and the cost of shelving, removal, and cataloguing, the Standing Committee could not at present see its way to express an opinion, and it deferred consideration to the annual meeting.

In regard to the binding of books, at a meeting of the Standing Committee held on the 27th October the Hon. Secretary reported that it might be possible to get binding done at a reasonable rate. It was resolved to appoint the Library Committee and Mr. Aston a committee with power to act in the matter.

Carter Library: On the 27th October it was resolved that the Hon. Mr. G. M. Thomson and Mr. Aston be a sub-committee to draft a letter defining the terms under which the Carter Library shall be deposited with the Alexander Turnbull Library, the committee to have power to act. The following recommendations of this committee were adopted at a meeting of the Standing Committee held on the 9th December:—

"The terms under which the New Zealand Institute is prepared to hand over to the custody of the Alexander Turnbull Library the Carter Library, contained in two book-cases now in the Dominion Museum Library, are as follows:—

"(1.) A complete catalogue of the Carter Library shall first be prepared by the assistant librarian (Miss Wood)—(*a*) as it exists at present; (*b*) any book known to be missing to be noted, and if possible recovered.

"(2.) The books, and cases in which they are kept, to be carefully removed by the Alexander Turnbull Librarian to a room which shall be agreed upon.

"(3.) That the Carter books shall thereafter while in the custody of the Alexander Turnbull Librarian be kept in the above cases and not removed from the room in which they are stored.

"(4.) Members of the Institute shall have the right to consult the books. subject to any rules which the Alexander Turnbull Librarian may think fit to impose to safeguard his responsibility for the safe-keeping of the books.

"(5.) That the Alexander Turnbull Librarian be responsible for the safe-keeping of the books.

"(6.) The Alexander Turnbull Librarian agrees to allow Mr. Elsdon Best, who is most frequently consulting the books, the use of a key in order that he may be unrestricted as heretofore in his study of the books.

"(7.) As the ownership of the Carter Library, by the terms of the deed of gift, is jointly vested in the Colonial Museum (now the Dominion Museum) and the New Zealand Institute, the formal consent of the Hon. Minister of Internal Affairs must be obtained.

"(8.) The insurance on the books to be paid by the New Zealand Institute.

"N.B.—The New Zealand Institute reserves the right to remove at any time the Carter Library to another building, and the fact that it is at present willing to house the collection in the Alexander Turnbull Library is forced upon the Institute owing to the danger of destruction by fire, and hopes to resume custody of it when a more suitable building is available for housing the collection."

In view of the financial conditions it has not been deemed expedient to approach the Government with reference to the establishment of a Technological Library (see Resolution of Science Congress, vol. 53, p. 490).

Revision of Exchange List.—On the 11th May the Library Committee was requested to draw up a further exchange list, and on the 22nd September the committee presented their report, and it was resolved to send a circular to all the suggested exchanges in the terms mentioned by the sub-committee, and to give effect to it generally.

Pan-Pacific Conference.—Letters were received from Canterbury Philosophical Institute, dated 1st September, and Otago Institute, dated 25th August, asking that the Institute take into consideration the advisability of inviting the Pan-Pacific Conference to meet in New Zealand in 1923. The matter was discussed at a meeting of the Standing Committee held on the 27th October, and the President reported that he had interviewed the Minister on the matter. On the 9th December letters from the Manawatu Philosophical Society and the Wanganui Philosophical Society were read, and it was resolved that the Standing Committee considers that the meeting of the Pan-Pacific Congress should be held in New Zealand, provided that the Government is not called upon to pay any expenses beyond those of the necessary printing in connection with the meeting.

International Research Council.—A letter, dated 21st July, from the General Secretary of the International Research Council urging the New Zealand Institute to send a representative to the Brussels Conference to be held on the 25th July, 1922, was read at a meeting of the Standing Committee on the 27th October, when it was decided that, in view of the present financial condition, the matter of representation be referred to the annual general meeting of the Board.

U.S.A. National Research Council. — On the 8th March Mr. Vernon Kellog, permanent secretary of the National Research Council in the United States of America, wrote suggesting that, in order to stimulate the scientific study of the Pacific region, special committees on Pacific investigations be appointed, and that steps be taken to bring together delegates from such interested countries, and that arrangements for forming a permanent organization be referred to such delegates. The President, Professor Easterfield, replied to this letter, stating that the scientific men of New Zealand would be deeply interested in the proposition to co-operate with the United States agency, and he would have pleasure in bringing the matter before the annual meeting of the New Zealand Institute.

Vacancy in the Board of Governors.—On the 11th May the Standing Committee passed a resolution of sympathy with the relatives of the late Mr. C. A. Ewen, formerly Hon. Treasurer of the New Zealand Institute. On the 8th June it was resolved to call the attention of the Hon. Minister of Internal Affairs to the vacancy occurring in the Board of Governors by the death of Mr. Ewen. On the 4th July Internal Affairs Department wrote intimating that Dr. Cockayne, F.R.S., had been nominated in Mr. Ewen's place. The appointment was gazetted on the 27th June, 1921. On the 21st December a *Gazette* notice was received notifying that Dr. J. A. Thomson and Mr. B. C. Aston had been reappointed representatives of the Government for the ensuing two years.

Broun Collection of New Zealand Beetles.—On the 9th November the Hon. Minister of Internal Affairs wrote regarding the collection of New Zealand beetles which Major Broun, who had died in August, 1919, had bequeathed to the British Museum. A proposal had been made to the British Museum authorities to allow the collection to remain in New Zealand for a period of five years, in order that a representative duplicate collection might be made for the purpose of reference by New Zealand entomologists. The British Museum authorities agreed that it be retained for two years, and made an alternative proposal that the collection be despatched forthwith, the Trustees of the Museum on their part undertaking to have compared and named by experienced entomologists all as-yet-unnamed insects in the Dominion Museum as may be desired, and any further collection of New Zealand insects which may be formed for the Dominion Museum within the next five years, and offering to have the comparison and naming done with all possible expedition, and to return the collections from time to time as the work is completed. The Minister intimated that, as the Broun trustees in Auckland will not permit entomologists to view the collection because of the fact that it was bequeathed to the British Museum, he proposed to agree to the request of the British Museum and allow it to go forward. On the 9th December the Standing Committee approved of the proposal.

Statutory Grant to the Institute.—A letter, dated 22nd November, from the Hon. Minister of Internal Affairs was received intimating the intention of the Government to reduce the statutory grant from £1,000 to £500. It was resolved at a meeting of the Standing Committee held on the 9th December to protest against the reduction, and a deputation waited upon the Hon. Minister. Later the Under-Secretary attended an adjourned meeting of the Standing Committee, and at his request it was decided to write fully stating the exact financial position of the Institute, and to assure him of the Institute's intention to carefully scrutinize all matter for publication in order that the printing bill might be reduced. On the 23rd December the Under-Secretary wrote that, in view of the representations made by the Institute, the matter had been reconsidered, and the Hon. Minister had directed that the full statutory grant of £1,000 be paid for the current year.

Life Members: Incorporated Societies Exchange.—The Wellington Philosophical Society wrote on the 20th September asking for some ruling on the matter of life-membership exchange between the various societies. The Standing Committee resolved to ask societies whether they consider it a wise policy for societies to agree that a life member of one society should on being transferred to another society and district become on application a member of that society. Societies were asked to reply in time for the matter to come before the annual meeting.

Catalogue of New Zealand Fishes.—This matter had been left in the hands of the Hon. Minister of Marine, who in October, 1920, promised that it should be considered with the estimates in 1921. No further information regarding the catalogue has been received.

Resolutions of the Standing Committee not otherwise mentioned in the Report.

1. On the 7th February it was resolved to keep a minute-book of future Science Congresses.

2. On the 9th March it was resolved that all applications for research grants should come to the Standing Committee with the full approval of some incorporated society, and that this be insisted upon in every case.

3. On the 9th March it was resolved that Broun's *Bulletin No. 1* (parts 6 and 7) should be printed in the most economical manner possible, and that the Hon. Editor be authorized to proceed in the matter of the other publications as reported.

4. On the 11th May it was resolved that 1,750 copies of the 53rd volume of *Transactions* be printed.

5. On the 11th May it was resolved that the amount of the Hector Prize be £45.

6. On the 22nd September it was resolved to authorize the publication of the final part of the late Major Broun's *Bulletin No. 1* (pt. 8).

7. On the 22nd September it was resolved that no action in regard to issuing the honorary members' certificates be taken at present.

8. On the 22nd September it was resolved that a quorum of four be necessary before the Standing Committee can transact business: this resolution to be confirmed at the annual meeting.

9. On the 9th December it was resolved that the price of Major Broun's *Bulletin*, parts 6 and 7, be 5s. each to non-members and 3s. 6d. each to members.

The following five items arising from the report were then dealt with:—

1. *Quorum.*—On the motion of Mr. Wright, seconded by Dr. Chilton, it was resolved, That the number of members required to form a quorum of Standing Committee be four.

2. *Hamilton Prize Fund.*—After hearing the President's explanation of the position which had arisen, on the motion of the Hon. Mr. Thomson, seconded by Professor Cotton, it was resolved, That the matter of the rules and regulations of the Hamilton Prize stand over till a committee, consisting of Professors Chilton, Farr, and Segar (convener), have reported on the question.

Later, the following report of the committee was received and adopted: "The committee, after considering the correspondence, recommend that a committee of two be appointed by the New Zealand Institute to confer with a similar committee of the Wellington Philosophical Society, and that the committee of the Institute be given power to act." The committee appointed was the Hon. Mr. Thomson and Dr. Cockayne.

3. *U.S.A. National Research Council.*—It was resolved that this should be considered in connection with the Pan-Pacific Congress later.

4. *International Research Council.*—On the motion of Dr. Cockayne, seconded by Mr. Eliott, it was resolved, That we take no action in the matter of the International Research Council.

5. *Life Membership Exchange.*—On the motion of Dr. Marshall, seconded by Dr. Tillyard, it was resolved, That the recommendations of the Philosophical Institute of Canterbury in regard to the transfer of life

members be adopted, and that the suggestion of the Canterbury Philosophical Institute be sent to every society. The recommendation is as follows: "That when a life member of an incorporated society takes up his residence in another district his name be retained on the roll of the original society, from which he should receive the *Transactions*, and the society of the district to which he transfers should grant him full membership privileges."

Financial.—A report from the Hon. Treasurer was received, and ordered to be incorporated in the Standing Committee's report. The reports of the Hon. Treasurer—namely, statement of receipts and expenditure, statement of liabilities and assets, statement of trust funds—were then considered, and the financial position of the Institute was discussed, and a tender for publishing the *Transactions* was received. On the motion of the Hon. Treasurer, the financial statements, all duly audited by the Auditor-General, were adopted.

Hon. Treasurer's Report.

Finances.—The statement of assets and liabilities shows that the credit balance, £31 15s. 10d., on 31st December, 1920, is now turned into a debit balance of £678 4s. 2d., so that our finances are £710 worse off. This is almost entirely due to the greatly increased cost of the annual volume of the *Transactions*.

The decision of the Standing Committee to transfer the funds of the Carter, Hector, and Hutton Trusts from the hands of the Public Trustee to New Zealand Government inscribed stock has proved a very wise step. The bonds were purchased at £91 5s., and to-day's quotations are £93 15s., showing a rise of £2 10s., which represents about £140 increase of capital. The rate of interest earned represents about £6 10s. per cent.

I would recommend that the books of the Institute should be kept under the double-entry system.

I desire to express my appreciation of the careful and accurate manner in which Miss Wood, the Assistant Secretary and Treasurer, has at all times kept the books and accounts of the Institute.

M. A. Eliott, Hon. Treasurer.

New Zealand Institute.—Statement of Receipts and Expenditure for the Year ending 31st December, 1921.

Receipts.	£	s.	d.
Balance at 31st December, 1920	2,536	2	5
Part Government statutory grant	250	0	0
Publications sold ..	96	14	3
Incorporated societies' levy	103	13	0
Government grants for research	405	0	0
Grants refunded by grantees	95	4	4
Interest (Endowment Fund) Post Office Savings-bank	61	12	6
Carter Bequest Fund, from Public Trustee ..	4,865	15	10
Interest, Carter Fund, from inscribed stock ..	12	9	8
Hector Memorial Fund, from Public Trustee ..	1,092	6	0
Interest, Hector Fund, from inscribed stock ..	41	19	0
Hutton Memorial Fund, from Public Trustee ..	924	8	3
Interest, Hutton Fund, from inscribed stock ..	35	5	2
(All interest to 15th July.)			
	£10,520	10	5

Expenditure.	£	s.	d.
Government Printer ..	750	0	0
A. A. Lawson, Sydney (coloured plates) ..	45	16	8
Travelling - expenses, Governors', annual meeting	33	7	8
Travelling-expenses, President, Standing Committee	24	3	4
Petty cash, postages, &c. ..	28	10	0
Petty cash, balance in hand	5	2	0
Salary	222	5	0
Le Grove Typewriting Company—Typewriter ..	28	10	0
Insurance premium ..	5	0	0
Bank commission ..	0	10	0
Lawyer's fee (opinion *re* trust funds)	3	3	0
Research grants, as per list	318	3	4
Carter Bequest inscribed stock	4,899	16	3
Hector Memorial inscribed stock	1,137	14	3
Hutton Memorial inscribed stock	945	19	3
Balance, as under ..	2,072	9	8
	£10,520	10	5

		£	s.	d.
Balance in—				
Bank of New Zealand	.. ..	49	11	3
Post Office Savings-bank	.. ..	2,022	18	5
		£2,072	9	8

Made up as follows:—	*Dr.* £	s.	d.	*Cr.* £	s.	d.
Endowment Fund	..			117	17	2
Balance Government research grants ..	..			1,450	6	1
Institute General Purposes Account ..	..			269	17	3
Library Fund	..			245	15	0
Carter Bequest Fund	21	10	9	..		
Hector Memorial Fund	3	9	3	..		
Hutton Memorial Fund	..			13	14	2
	25	0	0	2,097	9	8
				25	0	0
				£2,072	9	8

M. A. Eliott, Hon. Treasurer.

Examined and found correct.—G. F. C. Campbell, Controller and Auditor-General.

New Zealand Institute.—Statement of Liabilities and Assets at 31st December, 1921.

Liabilities.	£	s.	d.	£	s.	d.
Balance Government research grants				1,450	6	1
Balance Endowment Fund ..				117	17	2
Library Fund				245	15	0
Hutton Fund				13	14	2
Government Printer's Account—						
Balance outstanding account ..	157	0	2			
Broun's *Coleoptera*, pt. 6 ..	85	0	0			
Broun's *Coleoptera*, pt. 7 ..	60	0	0			
Index, Vols. 41 to 51 ..	46	10	0			
Stationery ..	4	7	0			
Extracts ..	102	14	6			
Vol. 53 ..	1,285	0	0			
				1,740	11	8
				£3,568	4	1

Assets.	£	s.	d.
Post Office Savings-bank ..	2,022	18	5
Bank of New Zealand ..	49	11	3
Balance in hand (petty cash)	5	2	0
Hector Fund	3	9	3
Carter Bequest	21	10	9
Sundry debtors	37	8	3
N.Z. Government statutory grant	750	0	0
Balance	678	4	2
	£3,568	4	1

To Balance .. .. £678 4s. 2d.

NEW ZEALAND INSTITUTE.—GOVERNMENT RESEARCH GRANTS FOR YEAR ENDING 31ST DECEMBER, 1921.

1921.			Dr. £ s. d.	Cr. £ s. d.
Jan. 1.	By	Balance on hand	..	1,268 5 1
Jan. 23.		Government grant	..	375 0 0
Mar. 24.		Government grant	..	25 0 0
Mar. 2.		Refund Messrs. Speight and Wild	..	7 0 0
Mar. 29.		Refund Mr. L. J. Wild	..	25 9 9
Mar. 31.		Refund Dr. Chilton	..	39 0 0
Aug. 2.		Government grant	..	5 0 0
Dec. 29.		Refund Dr. Adams	..	23 14 7
Jan. 1.	To	Professor Malcolm	10 0 0	
Jan. 17.		Professor Marsden	15 0 0	
Feb. 7.		Mr. H. D. Skinner	3 10 0	
Mar. 10.		Sir D. Hutchins's estate	25 0 0	
Mar. 10.		Professor Malcolm	40 0 0	
Mar. 14.		Professor Easterfield	16 0 0	
May 12.		Dr. Hilgendorf	21 18 11	
Aug. 3.		Mr. W. C. Davies	30 0 0	
Aug. 15.		Mr. A. M. Wright	25 0 0	
Sept. 27.		Mr. W. C. Davies	20 0 0	
Oct. 3.		Professor Easterfield	49 0 0	
Oct. 10.		Dr. Hilgendorf	17 16 11	
Oct. 11.		Mr. A. M. Wright	25 0 0	
Nov. 13.		Professor C. C. Farr	19 17 6	
			318 3 4	1,768 9 5
		Balance	1,450 6 1	..
			£1,768 9 5	£1,768 9 5

HUTTON MEMORIAL RESEARCH FUND.

Statement of Account, 1st January to 30th June, 1921.

Receipts.	£ s. d.	*Disbursements.*	£ s. d.
By Balance	898 19 5	To Balance to New Zealand Institute (payable to the Treasurer in pursuance of the the deed of trust)	924 8 3
Public Trust Office— Interest at ½ per cent., 31st March, 1920, to 31st December, 1920	3 5 3		
Interest at 5 per cent., 31st December, 1920, to 1st July, 1921	22 3 7		
	£924 8 3		£924 8 3

Statement of Account for the Year ending 31st December, 1921.

	Dr. £ s. d.	Cr. £ s. d.
Received from Public Trustee	..	924 8 3
To Purchase inscribed stock	945 19 3	..
By Interest	..	35 5 2
To Balance	13 14 2	..
	£959 13 5	£959 13 5

By Balance .. .. £13 14s. 2d.

Hector Memorial Fund.

Statement of Account, 1st January to 30th June, 1921.

Receipts.	£ s. d.	*Disbursements.*	£ s. d.
By Balance	1,062 0 0	To Balance to New Zealand Institute (payable to the Treasurer in pursuance of the deed of trust)	1,092 6 0
Public Trust Office—			
Interest at ½ per cent., 31st March, 1920, to 31st December, 1920	3 14 5		
Interest at 5 per cent. to 1st July, 1921 ..	26 11 7		
	£1,092 6 0		£1,092 6 0

Statement of Account for the Year ending 31st December, 1921.

	Dr. £ s. d.	*Cr.* £ s. d.
Received from Public Trustee	..	1,092 6 0
To Purchase inscribed stock	1,135 19 9	..
Interest	1 14 6	..
By Interest	..	41 19 0
Balance due to General Account	..	3 9 3
	£1,137 14 3	£1,137 14 3

To Balance .. .. £3 9s. 3d.

Carter Bequest.

Statement of Account, 1st January to 30th June, 1921.

RESIDUARY ACCOUNT.	*Dr.* £ s. d.	*Cr.* £ s. d.
By Balance	..	4,780 5 9
Public Trust Office—		
Interest to 30th June, 1921, at 5 per cent. ..	..	135 10 1
To Beneficiary's Account—		
Governors of New Zealand Institute—Cash ..	4,865 15 10	
Balance	50 0 0	
	£4,915 15 10	£4,915 15 10
By Balance	..	£50 0 0

LIABILITY.

Legacy—Museum and New Zealand Institute (payable when beneficiary complies with conditions in will) ..	..	£50 0 0

Statement of Account for the Year ending 31st December, 1921.

	Dr. £ s. d.	*Cr.* £ s. d.
Received from Public Trustee	..	4,865 15 10
To Purchase inscribed stock	4,883 18 5	..
Commission and charges	15 7 6	..
Interest	0 10 4	..
By interest due on £350	..	12 4 8
Refund fees	..	0 5 0
Balance due to General Account	..	21 10 9
	£4,899 16 3	£4,899 16 3

To Balance .. .. £21 10s. 9d.

Levy.—On the motion of the President, seconded by the Hon. Treasurer, it was resolved, That for every copy of volume 54 of the *Transactions* received by the incorporated societies a contribution of 5s. towards the cost of printing shall be made during the current year by such society.

Cost of Illustrations.—On the motion of Dr. Tillyard, seconded by Professor Segar, it was resolved, That in future the cost of making the blocks for plates and text-figures be charged to the authors.

Editing.—On the motion of Professor Marsden, seconded by Dr. Chilton, it was resolved, That it be an instruction to the Publications Committee to more severely edit the *Transactions* in future, particularly with regard to the length of papers.

On the motion of the President, seconded by Professor Farr, it was resolved, That the papers in hand be refereed not only from the point of view of suitableness but from the point of view of length.

Author's Copies.—On the motion of Hon. Mr. Thomson, seconded by Dr. Chilton, it was resolved, That for the future all author's copies over twenty-five be charged for.

Election of Fellows.—A ballot for the election of four Fellows resulted in the election of Mr. R. M. Laing (Christchurch), Professor E. Marsden (Wellington), Mr. P. G. Morgan (Wellington), and Professor D. M. Y. Sommerville (Wellington).

On the motion of Dr. Cockayne, seconded by Mr. W. G. Howes, it was resolved, That not more than two Fellows be elected in 1923.

Library Committee's Report.—The report of the Library Committee was read and adopted.

Report of Library Committee.

A number of foreign institutions which during the war had ceased sending publications have now resumed publishing, and consequently the incoming exchanges for the year have been more numerous. These have been received, registered, and placed upon the shelves as far as possible in the congested state of the library.

The Public Works Department was asked to report on the advisability of placing further shelving in the library. The question also of transferring the library to another building has been under discussion, and the matter is now referred to the annual meeting for a decision (see Standing Committee's Report).

During the year circulars were sent to members who had had books on loan for some considerable time, and as a result a fairly large number of books were returned to the library. An effort has also been made to complete the files of some of the serial publications presented to the library.

In the matter of binding, a sum of £245 15s. is still available, and, as prices are falling, the Hon. Secretary and the Library Committee have been authorized to invite quotations for binding some of the most widely read serials.

The Carter Library is to be removed to the Alexander Turnbull Library, and a commencement has been made to compile a complete catalogue of the books in the Carter Library prior to its removal.

Other Library Matters.—After explanation of the proposal to remove the library of the Institute to Victoria College had been made by Professor Kirk, it was resolved, on the motion of the Hon. Mr. Thomson, seconded by Professor Farr, That the Standing Committee be authorized to continue negotiations with the Professorial Board of Victoria College in regard to the housing of the New Zealand Institute library, with power to act if the finances permit.

Hutton Grant Report.—The report of Miss Mestayer, to the effect that she had been unable to do any work in connection with the grant during the last year, was received.

HUTTON RESEARCH GRANT FUND.

Miss Mestayer, who was granted £10 from the Hutton Fund, reports that she regrets that, partly owing to her College course and ill health, she has not been able to do any work on the Mollusca. She still holds a balance of £5, and is hoping to do some work next year.

Hector Memorial Award for 1922.—The recommendation of the Hector Award Committee was then received in a sealed envelope and read.

REPORT OF THE HECTOR AWARD COMMITTEE, 1922.

The committee consists of the President of the New Zealand Institute, Sir Ernest Rutherford, and Professor F. D. Brown. The committee unanimously recommends that the Hector Prize and Medal be awarded to Professor C. Coleridge Farr, D.Sc., for his researches in physical science, and more particularly for his work in connection with the magnetic survey of New Zealand.

THOMAS H. EASTERFIELD,
Convener of the Committee.

The recommendation that the Hector Medal and Prize should be given to Professor C. Coleridge Farr for his researches in physics was unanimously adopted.

Publications Committee's Report.—The report of the committee was read and adopted.

REPORT OF PUBLICATIONS COMMITTEE.

Fifty-three papers, by thirty-eight authors, were accepted for publication in volume 53 of the *Transactions of the New Zealand Institute*, and the volume was issued on the 31st August, 1921. It is slightly larger than the previous volume, containing xxxiv plus 584 pages (of which 98 are devoted to Proceedings and Appendix), 70 plates (two coloured), and a large number of text-figures. The full and good illustration the extra number of plates implies, whilst it adds somewhat to the cost, adds greatly to the value and general interest of the volume.

Two bulletins were issued during the year, being Parts 6 and 7 of *Bulletin No. 1*; and the Index to volumes 41–51 was also issued. Part 8 (the final) of *Bulletin No. 1* is in the printer's hands, and Dixon's *Mosses* is in print.

For the Committee,
JOHANNES C. ANDERSEN, Hon. Editor.

Regulations Committee.—The Hon. Secretary read the report of this committee and asked that it be reappointed for another year.—Adopted.

REPORT OF REGULATIONS COMMITTEE.

The committee has completed the tabulation of matter, which should be consolidated and put permanently on record, either as a gazetted regulation or as a resolution.

The committee considers it advisable to await the result of the annual meeting before printing its findings, and asks to be reappointed for another year.

Report of the Committee on Cataloguing was read, as follows:—

The committee recommends—

1. That each of the libraries in the Dominion be asked to supply a list of the periodicals and sets of publications which they possess, with the year at which the set began, in the subjects of the following list: Mathematics, physics, chemistry, geology, palaeontology, botany, zoology, ethnology, and psychology.

2. That a list be compiled and printed containing the brief titles of such periodicals and publications, with a reference to the libraries in which they are contained.

3. That the extension of this to include the applied sciences be held over in the meantime.

4. That, as soon as may be, detailed information be obtained from the various libraries with regard to the completeness of their sets, and that this information be incorporated in a card catalogue. Four copies of this catalogue should be prepared, one for each of the principal centres.

5. That an advisory committee be appointed (*a*) to assist the editor in determining what publications should be included in the list under No. 1, and (*b*) to determine the form in which the information required under No. 4 shall be provided.

Paragraphs Nos. 1, 2, and 3 were adopted. No. 4 was adopted with the deletion of the last sentence and the substitution of one reading, "Copies of this catalogue should be prepared." No. 5 was adopted with the addition of the words, "Mr. Archey shall be the hon. editor of this catalogue, and, with Professor Farr, Professor Chilton, and Mr. A. M. Wright, form the advisory committee."

Pan-Pacific Congress.—On the motion of Dr. Marshall, seconded by Professor Chilton, it was resolved, That every endeavour be made by the New Zealand Institute to make arrangements for the next Pan-Pacific Congress to be held in New Zealand in 1923. Drs. Chilton and Tillyard gave an account of the last Congress. It was resolved that Dr. Marshall, Hon. Mr. Thomson, and the President be a committee to further the above resolution.

Carter Bequest Committee Report.—The majority report, dated the 27th January, 1922, of the Carter Bequest Committee, signed by Dr. C. E. Adams, Mr. Thomas Forsyth, Mr. A. C. Gifford, Mr. P. Levi, and Professor E. Marsden, and the minority report, signed by Professor Kirk, were read. The reports from Mr. Martin Chapman, K.C., and Mr. E. D. Bell were read by the President. It was resolved, on the motion of Professor Marsden, seconded by Dr. Cockayne, That a committee be set up to prepare plans and estimates on the lines of the majority report for submission to the Board of Governors next year, provided that legal power can be obtained for using this money as indicated; the committee to consist of the President, Dr. Adams, Professor Farr, Professor Sommerville (convener), Professor Marsden, and Mr. Ward, of Wanganui.

Correspondence.—Letters from the Hon. the Minister of Internal Affairs, dated 5th February and 8th September, were read and received.

A letter from the Wellington Philosophical Society, dated 20th January, 1922, was read, and, on the motion of the President, it was resolved, That this Institute's Board of Governors urges upon the Minister of Internal Affairs the necessity of continuing the *Journal of Science and Technology*, which has filled a very important place in the science of the Dominion.

A letter dated 21st January, 1922, from the Nelson Institute, intimating a change in the name of the scientific branch, was read and received.

A letter from the Brett Company (Auckland), dated 27th January, 1922, was read and received, and, on the motion of Dr. Tillyard, it was resolved, That it be a recommendation to the Publications Committee that it interview the Government Printer towards getting a reduction of the Government Printer's Account.

Research Grant Committee's Report.—This was taken as read.

Report of the Research Grant Committee, 1921.

Dr. C. E. Adams, who in 1919 was granted £55, through the Wellington Philosophical Society, reported on the 21st December, 1921, that difficulties had arisen in purchasing any further instruments for the Astronomical Section. The British Astronomical Association, who retains the balance of the grant in order that they may purchase the instruments whenever opportunity occurs, reported that an offer of an objective prism had been made to them, but on examination it proved so poor in definition that the offer was not accepted. Great difficulty is anticipated in finding a prism within the sum allocated for this instrument, but the Astronomer Royal has been asked to assist in this matter, and it is hoped that early in the year 1922 the optical parts will be bought in England and sent to New Zealand.

Dr. Adams, who in 1919 was granted £150 through the Wellington Philosophical Society for an investigation in astronomical and geophysical sites, reported on the 21st December that the instruments which had been purchased were still in use in different stations in Otago, in charge of the Astronomical Branch of the Otago Institute, for the purpose of obtaining a year's observations at the different sites. No results had so far been published, but it is hoped to have a report comprising the observations for a year at least at each station ready for the American Eclipse Expedition which will pass through New Zealand next June. The balance of the grant is £123 14s. 7d., and of this Dr. Adams had £23 14s. 7d., which he refunded. He asks that the instruments may be retained for another year, and suggests that they then be handed over to Internal Affairs Department for future use in similar investigations.

Mr. G. Brittin, who in 1919 was granted £100, through the Philosophical Institute of Canterbury, for a research on fruit-diseases, reported on the 12th January, 1922, that the year's work consisted in pruning, spraying, and observing the results of the previous year's work. Pruning was done in the same manner as last year, with the result that the trees are growing strong, with plenty of foliage and fruiting-wood. The spraying results are also eminently satisfactory, there being a heavy crop of fruit, and the disease very much reduced, whereas in the check trees the crop is practically nil. As the grower in whose orchard the experiments are made is doing the spraying free of charge, being satisfied with the results of last season's work, Mr. Brittin has had no occasion to expend any of his grant, and the balance remains at £97, £17 being in hands of grantee.

Dr. Charles Chilton, who in 1918 was granted £50, through the Philosophical Institute of Canterbury, for an investigation of New Zealand flax, had been unable to complete this research owing to the absence of his assistant in Edinburgh, and in accordance with a resolution of last annual meeting refunded the unexpended balance of £44.

Dr. Kathleen M. Curtis, who in 1920 was granted £100, through the Nelson Institute, for research in parasitic mycology, reported on the 29th November that the partial immunity to black spot of four varieties of pear and three of apple, and to brown-rot of three varieties of peach, one of nectarine, and two of plum, has been investigated. She intends before concluding the work to examine three more varieties of apple, one of peach, and one of nectarine. A portion of the grant, £21 3s., has been expended in books, and the balance, £78 17s., still in the hands of the Institute, will be spent in a similar direction.

Professor T. H. Easterfield, who in 1919 was granted £200, through the Wellington Philosophical Society, for an investigation into the mineral oils, waxes, and resins of New Zealand, reported on the 24th December that the work carried out with the aid of this grant was epitomized in a paper read before the Science Congress in January, 1921 (see *Trans. N.Z. Inst.*, vol. 53, p. 516). More material has been received during the year, and the investigation is approaching completion. During the year £45 0s. 6d. has been spent in the salary of a part-time assistant. The balance in hands of grantee is £8 0s. 6d.

Professor W. P. Evans, who in 1921 was granted a further £200, through the Philosophical Institute of Canterbury, for an investigation of New Zealand brown coals, reported on the 16th December, 1921, that—(*a*) Calorific values previously determined had been checked where necessary, and further determinations made by Mr. Gilling; (*b*) producer runs where apparently abnormal had been checked, and further work of more detailed character with resinous brown coals had been carried on; (*c*) further runs with tandem producers had been made. Mr. Gilling had received an offer of permanent work, which he had accepted, and all attempts to procure a new assistant had proved useless; but it is hoped that next year two graduates will be able to assist. No portion of the work has been published, but the whole report is now undergoing its final checking, and should be ready early next year. The further £200 has not been touched, and the balance to the credit of this research is £244 8s. 6d., £24 8s. 6d. of which is in the hands of the grantee.

Professor C. Coleridge Farr, who in 1919 was granted £100, through the Philosophical Institute of Canterbury, for a research on porcelain insulators, reported on the 18th November that much work had been done during the year, and very conclusive results and valuable data had been accumulated, and it is hoped to publish a paper giving the fullest details very soon, as the subject is of the utmost importance not only to the Dominion but to all users of high-tension insulators throughout the world. The tests for porosity devised by the authors of this paper, Dr. Farr and Mr. H. E Philpott, have been adopted by the Government as a part of the acceptance tests to be applied to insulators coming into the Dominion, and it is hoped that the application of such tests will result in a considerable and very desirable improvement in

insulator-manufacture. The grant has been overexpended, and the grantee has asked that £60 might be transferred from his grant for gas-free sulphur to the porcelain grant, in order that the work might be completed. Professor Farr has deposited with the Hon. Secretary a 48-paged manuscript copy of his paper.

Professor Farr, who in 1920 was granted £75, through the Philosophical Institute of Canterbury, for a research on the properties of gas-free sulphur, reported on the 15th November that work on this research had gone on during the year, but so far no expense had been incurred, and the grantee has not received any part of the grant. It is hoped shortly to publish a paper giving the results of this investigation.

Mr. George Gray, who in 1920 was granted £50, through the Philosophical Institute of Canterbury, for an investigation on the waters of Canterbury, reported on the 24th December that about 130 samples of water had been collected from deep and shallow wells in the Lincoln district, and also from the Selwyn and Waimakariri Rivers at intervals in their courses. In these samples the amount and nature of the dissolved matter have been estimated and recorded for future use. The expenses so far have been trifling, and the grantee has not received any portion of the grant, which he requests may be made available for another year.

Dr. F. W. Hilgendorf, who in January, 1921, was granted £100, through the Philosophical Institute of Canterbury, on behalf of the Artesian Wells Committee of that Institute, reported in December that in February and March four continuous recorders for reading the static level of waters in wells were made by the Physics Department of Canterbury College, and these were installed on three wells in Christchurch and on the River Avon. Much difficulty of a mechanical nature was experienced in obtaining satisfactory records, but this was finally overcome and a good series of records made. The instruments have now been moved to some wells near Lincoln for the purpose of eliminating the disturbance of the water in the wells by industrial use of those in the neighbourhood. When a sufficient series of records is secured, the work of comparing them and of attempting explanations of the fluctuations of the water can be undertaken. The sum of £39 14s. has been expended in shelters for recorders, piping for connecting wells with recorders, maintenance of instruments, &c. No permanent scientific material has been purchased, the recorders being on loan by Canterbury College, and iron piping will as far as possible go back to the suppliers. Dr. Hilgendorf asks that the remainder of the grant, £60 4s. 2d., in hands of the Institute, may be available for another year.

Professor R. Jack, who in 1917 was granted £25, through the Otago Institute, for an investigation of the electric charge on rain and its connection with meteorological conditions, has been absent in England, and on the 27th December he applied for a renewal of this grant. Grantee holds the balance, £25.

Mr. T. L. Lancaster, who in 1919 was granted £50, through the Auckland Institute, for an inquiry into the rate of growth of the principal New Zealand timber-trees, reported on the 19th December that it had been found impossible to devote much time to this research, and very little headway had been made. A number of kauri saplings in the Titirangi district have been marked with permanent labels and are being kept under observation. It is now certain that young kauri poles and saplings may suspend height-growth for a whole year, or possibly longer. It is proposed to extend observations to discover what external influences, if any, are concerned in this temporary cessation of height-growth, and whether it is correlated with increased growth in thickness. Observations on the growth-rings have been continued, a number of microphotographs have been made, and a quantity of data collected, but it is not at present possible to make definite statements about these. Next year it is proposed to begin a series of observations on specimens of kauri growing in an area of forest at Swanson. Balance of grant is £49, of which the Institute holds £35 and the grantee £14.

Professor J. Malcolm, who in 1919 was granted £250, and in 1920 a further £175, through the Otago Institute, for a research on the composition of New Zealand fishes, reported in June that his assistant, Mrs. Johnson, had completed, and sent in for publication in the *Transactions*, part 2 of her papers on the food values of New Zealand fishes. At present she is unable to continue the work, and Professor Malcolm's visit to England has prevented him from carrying on any further research. While on tour he proposes to buy apparatus for carrying on the work on his return, and asks that the Board of Governors should allow him to continue next year with the unexpended part of the grant, which is £150, and is in the Institute's hands.

Mr. W. G. Morrison, who in 1918 was granted £100, through the Philosophical Institute of Canterbury, for a research in afforestation of the Spenser Ranges, reported on the 10th January, 1922, that since his last report further photographs had been taken, and useful data was noted on his excursion through the North Island with Professor Wilson of Harvard University. Much evidence had been accumulated in support of his proposal of "natural afforestation," and an experiment is to be made

at Balmoral Station along the lines of his suggestion—namely, to plant groups of lines of certain species at distances of several chains apart, in order to allow them to fill the intervals by natural seeding. Mr. Morrison applied for an extension of the grant for another year. Expenditure amounted to £16 5s., and the balance of the grant is £56 19s. 5d., of which grantee holds £29 19s.

Mr. R. Speight, who in 1919 was granted £225, through the Philosophical Institute of Canterbury, for a geological survey of Malvern Hills, reported in December, 1921, that a student, acting under his direction, had made a survey of that portion of the Malvern Hills area known as Cordy's Flat, the general result of which is to indicate the probable extension of the field under a portion of the flat. This is being worked now as a commercial source of coal with fair prospects of success, subject to the limitation of results obtained in other parts of the area, that the coal-seams are lens-shaped and do not continue for long distances either in the direction of the strike or the dip. This may prove an exception, but there are strong hopes to the contrary. The true extension of the coal in this area can only be determined by further work or by boring. Promising results have also been obtained from examination of the area in the vicinity of Glentunnel and of the country to the south of the Selwyn River. Work has also been commenced at Glentunnel, the extreme western portion of the area, near the Rakaia Gorge. Owing to the non-appointment of a research assistant at Canterbury College, it was found impossible to commence the work of examining the physical and chemical properties of the clay and sands, and it is difficult to suggest any satisfactory way for this being carried out at present. It is possible that an arrangement may be made with an ex-student of Canterbury College, and that this side of the work may be properly developed. The cost of the work for the year amounts to £9 15s. 6d., and the balance of the grant stands at £200, of which the grantee holds £25 1s.

Messrs. R. Speight and L. J. Wild, who in 1916 were granted £50, through the Philosophical Institute of Canterbury, for an investigation of the phosphate-yielding rocks of Canterbury, in accordance with a resolution of last annual meeting, refunded the unexpended portion of their grant—namely, £7.

Mr. L. J. Wild, who in 1918 was granted £30, through the Philosophical Institute of Canterbury, for a soil-survey in Canterbury, in accordance with a resolution of last annual meeting, refunded the unexpended portion of his grant—namely, £25 9s. 9d.

Mr. A. M. Wright, who in 1921 was granted £75, through the Philosophical Institute of Canterbury, for a research on the vitamine content of commercial meat products, reported in January, 1922, that this investigation was carried out in the biological department of Canterbury College, and covered the determination of vitamin A and B in fresh and cold-storage meats, and the determination of vitamin A in pasteurized and non-pasteurized oleo-margarine. The main work has now been completed, and should be available for publication shortly. Some points remain to be cleared up, consequently the continuance of the grant is requested. A sum of £36 1s. 5d. has been expended, and the balance of the grant is £38 18s. 7d., of which £13 18s. 7d. is in grantee's hands.

Professor E. Marsden, who in 1919 was granted £125, through the Wellington Philosophical Society, for a research on the effect of *a* particles of radium, reported on the 13th January, 1922, that the research is in vigorous prosecution. Radium has been purchased and is in process of measurement. This measurement is carried over many months, to ascertain purity of radium. Special experiments are being directed to ascertain whether or not there is an extra terrestrial radiation of radio-active nature. For this purpose measurements were made in the tropics (Samoa), at Mount Egmont, and will be made on Ruapehu in a few weeks. Total expenditure amounts to £44 9s. 4d., and the balance is in the hands of the Institute.

Professor Marsden, who in 1919 was granted £60, through the Wellington Philosophical Society, for a research on coal efficiency, reported on the 13th January, 1922, that the remaining money from this grant is being used to investigate the efficiency of electric and other illuminants used for domestic purposes. There is a balance of £5 2s 6d. in the hands of the Institute.

Professor Marsden, who in 1920 was granted £50, through the Wellington Philosophical Society, for a research on the physical properties of New Zealand timbers, reports that there is an unexpended balance of £17 14s. 7d. in the hands of the Institute.

In regard to the manuscripts of the late Sir David Hutchins, Mr. E. P. Turner reports that Mr. Morris Jones is unable to undertake the work of collation, and it is desirable that steps be taken to have some report made by a competent person as to the best course to pursue in the matter.

During the year the following further applications for research grants were granted: Professor Burbidge, through the Auckland Institute, £100 for research on wireless telegraphy; Mr. W. C. Davies, through the Nelson Institute, £50 for research in soil bacteria and protozoa; Professor T. H. Easterfield, £200, through the Nelson

Institute, for research on orchard fruit; Mr. D. Milligan, £50, through the Nelson Institute, for research on New Zealand orthoptera. Later applications from Mr. H. D. Skinner (Otago Institute), Professor Wall (Philosophical Institute of Canterbury), Mr. Yeates (Wellington Philosophical Society), Professor E. Marsden and Mr. Harwood (Wellington Philosophical Society), and Mr. L. Bastings (Otago Institute) were declined owing to the absence of any funds available for research purposes. This committee recommends that grantees should ask the approval of the Standing Committee before purchasing any apparatus which they may require for their researches.

A property list of all apparatus in the hands of the Institute and of the individual grantees has been compiled, and at the request of the Under-Secretary for Internal Affairs a copy has been deposited with him.

It was resolved, That the Standing Committee shall make inquiry and act with regard to the requests of Dr. Adams regarding the instruments used in his grant. It was resolved to ask the Minister for a further £250 to be reinstated on next year's estimates.

Travelling-expenses.—It was resolved, That travelling-expenses of the Board of Governors be paid.

Diamond Jubilee.—Mr. A. M. Wright extended an invitation to the members of the Board to the Diamond Jubilee of the Philosophical Institute of Canterbury, at which he suggested the medal for the Hector Award should be presented to Professor Farr on the 5th April.

Forest Policy.—On the motion of the President, seconded by Dr. Chilton, it was resolved, That this meeting of the New Zealand Institute hereby expresses its appreciation of the successful efforts of Sir F. D. Bell on behalf of New Zealand forestry.

Honorary Members.—The death of Dr. W. S. Bruce was announced, this creating a vacancy in the roll of honorary members to be filled at the annual general meeting in January next. On the motion of Dr. Cockayne, it was resolved, That the nominations of honorary members be sent to the Governors at least fourteen days before the annual meeting.

Fireblight.—On the motion of Dr. Tillyard, seconded by Dr. Cockayne, it was resolved, That, in view of the southward spread of fireblight to Patea during the year, this meeting desires to urge upon the Minister of Agriculture the great necessity for establishing, as soon as possible, special orchard areas within which the elimination of hawthorn should be carried out along lines to be approved by the Hon. Minister.

Officers for Year 1922.—The election of officers resulted as follows: President, Professor Kirk; Hon. Secretary, Mr. B. C. Aston; Hon. Treasurer, Mr. M. A. Eliott; Hon. Editor, Mr. Johannes C. Andersen; Hon. Librarian, Dr. J. Allan Thomson; Hon. Trustees of the Carter, Hector, and Hutton Trust Funds, Hon. Secretary and Hon. Treasurer.

Election of Committees.—Library Committee: Reappointed.

Publications Committee: Reappointed, with the addition of Professor Marsden.

Research Grant Committee: Reappointed.

Regulations Committee: Reappointed.

Hector Award Committee: Professor Charles Chilton (convener), Professor Haswell, Sydney, and Mr. T. F. Cheeseman, Auckland. (Subject, zoology.)

Date and Place of next Annual Meeting.—To be held in January, 1923; day to be fixed by Standing Committee.

Votes of Thanks to the President and other honorary officers were carried by acclamation.

CONTRIBUTORS TO PUBLICATION FUND.

The cost of publishing the annual volume of the *Transactions* having increased greatly, a circular stating the position and inviting contributions towards expense of publication was sent to every member of the affiliated societies in March, 1922. The following lists contain the names of all who responded to the circular, their contributions being 10s. unless a larger sum is indicated, and the President takes the earliest opportunity of acknowledging these donations. Four contributors of 10s. each did not enclose name or any means of identification, the envelopes bearing the postmarks of Christchurch, Dunedin, Hawera, and Waihemo.

Wellington Philosophical Society.

Adkin, G. L.
Andersen, J. C.
Aston, B. C. (£1 1s.).
Atkinson, E. H.
Baillie, H. (£1).
Bennett, Francis.
Best, Elsdon.
Birks, L.
Blair, D. K.
Brandon, A. de B.
Burnett, J.
Campbell, J.
Carter, W. H.
Chapman, Martin (£1).
Cockayne, L., Ph.D.
Cockcroft, T.
Cotton, C. A., D.Sc. (£1 1s.).
Coventry, Mrs. H.
Ellis, E. McIntosh.
Ferguson, William.
Ferrar, H. T.
Fletcher, Rev. H. J.
Freeman, C. J.
Frengley, Dr.
Gavin, W. H.
Gibbs, Dr. H. E.
Goudie, H. A.
Grange, L. I.
Gray, W.
Hamilton, H.
Hardy, J. C. (£1 1s.).
Hector, C. Monro, M.D. (£1 1s.).
Helyer, Miss E.
Hislop, J.
Holmes, R. W.
Hudson, G. V.
Jones, A. Morris.
Kirk, Professor H. B. (£1).
Lomax, Major H. A. (£1).
McDonald, J.
Maclaurin, Dr. J. S.
MacLean, F. W.
McSherry, H.
Marsden, Professor E.
Maxwell, E.
Maxwell, J. P.
Moore, G.
Moorhouse, W. H. Sefton (£2 2s.).
Morgan, P. G. (£1).
Myers, J. G.
Neill, W. T.
Ongley, M. A.
Orr, Robert.
Phillipps, W. J. (12s. 6d.).
Phillips, Coleman (£1).
Pilcher, E. G.
Richardson, C. E.
Robinson, I. R.
Roy, R. B. (£1).
Turner, E. Phillips.
Waterworth, A. (£1).
Webb, E. N.
Wilson, Sir James.
Wynne, H. J.

Auckland Institute.

Alexander, J.
Algie, R.
Allum, John.
Barr, J. M.
Bartrum, J. A. (£1).
Bates, T. L.
Bishop, J. J.
Brown, Professor F. D. (£1).
Buddle, H. D.
Bush, W. E.
Carter, M.
Chatfield, Dr. H. A. (£1 1s.).
Cheeseman, T. F.
Clark, M. (10s. 6d.).
Coleman, J. W.
Cooper, A. N.
Crook, J.
Dearsly, H.
Dennin, J.
Downard, F. N. R.
Duder, R. W.
Eady, A.
Fenwick, R.
Firth, R. W.
Fisher, F. S.
Fleming, J. (£1 0s. 6d.).
Florance, R. S. (£1 1s.).
Frater, J. W.
Frater, Captain W.
Gilfillan, H.

Auckland Institute—*continued.*

Gray, S.
Herries, Sir W. H.
Hovell, S. W.
Ick-Hewins, Dr.
Johnson, H. Dunbar.
Knight, G.
Lancaster, T. L.
Lewisham, W. C.
Leys, T. W.
Lunn, A. G. (£1).
McDonald, Rev. W.
Mackay, J. G. H.
Major, C. T.
Mason, Mrs. F.
Matthews, H. B.
Miller, E. V. (£1).
Morton, H. B.
Murray, G. T.
Oliver, W. R. B.
Petrie, D. (£1).
Philcox, T. (£1 1s.).
Pountney, W. H.
Poynton, J. W.
Robb, J.
Shakespear, Mrs. R. H.
Simson, T.
Smith, H. G. (£1 0s. 6d.).
Stanton, J.
Stevenson, A. G.
Stewart, D. F.
Tinne, H.
Tunks, C. J. (15s.).
Upton, P.
Upton, S.
Williamson, C.
Wilson, J. A.
Wilson, J. M.
Wilson, John.
Wilson, W. R.
Winklemann, H.
Worley, Professor F. P.
Yates, E. (£1).

Philosophical Institute of Canterbury.

Acland, Dr. H. T. D. (£1 1s.).
Aldridge, W. G.
Allison, H.
Allan, H. H. (£1).
Anderson, Mrs.
Archey, G. E.
Askew, H. O.
Bevis, Miss J. F.
Bamford, P. G.
Bowker, G.
Bradley, Orton (£2).
Brittin, Guy.
Broadhead, H. D.
Campbell J. W. (£1).
Chilton, Professor C.
Coles, W. R.
Condliffe, Professor J. B.
Cowley, S. R. (£1).
Cuthbert, Mrs. T. Y.
Dash, C.
Deans, W.
Dorrien-Smith, Major A. A.
Drummond, J.
Evans, Professor W. P. (£1 1s.).
Farr, Professor C. C. (£1).
Foweraker, C. E. (7s. 6d.).
Giles, E. D.
Gilling, C. D.
Godby, M. H. (12s. 1d.).
Goss, W.
Graham, C. H. E.
Grigg, J C. N. (£1 0s. 6d.).
Hamilton, W. M.
Haszard, H. D.
Herriott, Miss E. M.
Hogg, H. R.
Holloway, Rev. J. E. (£1 1s.).
Howard, E. J.
Jameson, J. O. (£1).
Jamieson, W. G. (£2 2s.).
Jobberns, G. (£1).
Kitchingman, Miss.
Laing, R. M.
Macbeth, N. L.
McKellar, A.
McGillivray, Robert.
Marsh, H. E.
Pairman, Dr. J. C.
Pairman, Dr. T. W. (£1 0s. 6d.).
Penlington, G.
Prudhoe, J. C.
Reece, W.
Rhodes, J. H. (£1).
Rhodes, Hon. Sir Heaton (£1 1s.).
Robinson, R. G.
Scott, G. (£1 1s.).
Skinner, W. H.
Stead, E. F.
Symes, L. P.
Taylor, G. J.
Thomas, Dr. J. R.
Tripp, C. H.
Waddell, J. (10s. 6d.).
Waller, F. D.
Way, G. E.
Widdowson, Dr. H. L. (£1 1s.).
Wigram, Hon. H. F.
Wild, L. J.
Wardrop, J. H. W.

Otago Institute.

Angell, S.
Barnett, Dr. L. E.
Begg, J. C. (£1).
Benham, Professor W. B. (£1).
Benson, Professor W. N.
Black, A. (£1).
Brasch, H.
Brent, D.

OTAGO INSTITUTE—*continued.*

Buchanan, N. L.
Cameron, Dr. P. D.
Chamberlain, C. W.
De Beer. I. S.
Edgar, James.
Farnie, Miss W.
Fels, W.
Fenwick, Cuthbert.
Fenwick, Sir George (£2 2s.).
Ferguson, Dr. H. L. (£1 1s.).
Finlay, H. I.
Garrow, Professor J. M. E.
Hoffmann, G.
Howes, W. G. (£8 12s. 8d.).
Jeffery, J.
Johnson, J. T. (£1 0s. 6d.).
McCurdie, W. D. R. (£1 1s.).
Malcolm, Professor J.
Milnes, J. W.
Park, Professor J. (£1 1s. 6d.).
Sandle, Major S. G.
Simpson, G.
Stout, Sir Robert.
Theomin, D. E.
Thomson, Hon. G. M. (10s. 7d.).
Williams, W. J.

HAWKE'S BAY PHILOSOPHICAL SOCIETY.

Anderson, A.
Chambers, Bernard.
Chambers, J. (£2 2s.).
Clark, T. P.
Duncan, Russell.
Harding, J. W.
Holdsworth, J.
Humphrey, E. J. (£1 1s.).
Large, J. S.
McLean, R. D. D.
Morris, W. (5s.).
O'Ryan, W. (£1).

NELSON INSTITUTE.

Curtis, Dr. K. M.
Curtis, W. S.
Easterfield, Professor T. H.
Gibbs, F. G.
Gibbs, Dr. S. A.
Johnston, Dr. W. D. S.
Mules, Right Rev. C. O.
Philpott, A.
Rigg, T.
Tillyard, Dr. R. J. (£1).
Turnbull, T. A.

MANAWATU PHILOSOPHICAL SOCIETY.

Akers, H. (£1).
Batchelar, J. O.
Bendall, W. E. (£1).
Bett, Dr. D. H. B.
Cunningham, G. H. (£1).
Eliott, M. A. (£2).
Gerrand, J. B.
Larcomb, E.
Murray, J.
Stowe, Dr. W. R.
Welch, W. (£1).
Wilson, Miss D.

WANGANUI PHILOSOPHICAL SOCIETY.

Bassett, W. G. (£1).
Liffiton, E. N.
Murdoch, R. (£2 2s.).
Sturge, H. E.
Ward, J. T. (£1 1s.).

POVERTY BAY INSTITUTE.

Tiffin, G. W.

APPENDIX.

NEW ZEALAND INSTITUTE ACT, 1908.

1908, No. 130.

An Act to consolidate certain Enactments of the General Assembly relating to the New Zealand Institute.

Be it enacted by the General Assembly of New Zealand in Parliament assembled, and by the authority of the same, as follows:—

1. (1.) The Short Title of this Act is the New Zealand Institute Act, 1908.

(2.) This Act is a consolidation of the enactments mentioned in the Schedule hereto, and with respect to those enactments the following provisions shall apply:—

(*a.*) The Institute and Board respectively constituted under those enactments, and subsisting on the coming into operation of this Act, shall be deemed to be the same Institute and Board respectively constituted under this Act without any change of constitution or corporate entity or otherwise; and the members thereof in office on the coming into operation of this Act shall continue in office until their successors under this Act come into office.

(*b.*) All Orders in Council, regulations, appointments, societies incorporated with the Institute, and generally all acts of authority which originated under the said enactments or any enactment thereby repealed, and are subsisting or in force on the coming into operation of this Act, shall enure for the purposes of this Act as fully and effectually as if they had originated under the corresponding provisions of this Act, and accordingly shall, where necessary, be deemed to have so originated.

(*c.*) All property vested in the Board constituted as aforesaid shall be deemed to be vested in the Board established and recognized by this Act.

(*d.*) All matters and proceedings commenced under the said enactments, and pending or in progress on the coming into operation of this Act, may be continued, completed, and enforced under this Act.

2. (1.) The body now known as the New Zealand Institute (hereinafter referred to as "the Institute") shall consist of the Auckland Institute, the Wellington Philosophical Society, the Philosophical Institute of Canterbury, the Otago Institute, the Hawke's Bay Philosophical Institute, the Nelson Institute, the Westland Institute, the Southland Institute, and such others as heretofore have been or may hereafter be incorporated therewith in accordance with regulations heretofore made or hereafter to be made by the Board of Governors.

(2.) Members of the above-named incorporated societies shall be *ipso facto* members of the Institute.

3. The control and management of the Institute shall be vested in a Board of Governors (hereinafter referred to as "the Board"), constituted as follows:—

The Governor:
The Minister of Internal Affairs:
Four members to be appointed by the Governor in Council, of whom two shall be appointed during the month of December in every year:

Two members to be appointed by each of the incorporated societies at Auckland, Wellington, Christchurch, and Dunedin during the month of December in each alternate year; and the next year in which such an appointment shall be made is the year one thousand nine hundred and nine:

One member to be appointed by each of the other incorporated societies during the month of December in each alternate year; and the next year in which such an appointment shall be made is the year one thousand nine hundred and nine.

4. (1.) Of the members appointed by the Governor in Council, the two members longest in office without reappointment shall retire annually on the appointment of their successors.

(2.) Subject to the last preceding subsection, the appointed members of the Board shall hold office until the appointment of their successors.

5. The Board shall be a body corporate by the name of the "New Zealand Institute," and by that name shall have perpetual succession and a common seal, and may sue and be sued, and shall have power and authority to take, purchase, and hold lands for the purposes hereinafter mentioned.

6. (1.) The Board shall have power to appoint a fit person, to be known as the "President," to superintend and carry out all necessary work in connection with the affairs of the Institute, and to provide him with such further assistance as may be required.

(2.) The Board shall also appoint the President or some other fit person to be editor of the Transactions of the Institute, and may appoint a committee to assist him in the work of editing the same.

(3.) The Board shall have power from time to time to make regulations under which societies may become incorporated with the Institute, and to declare that any incorporated society shall cease to be incorporated if such regulations are not complied with; and such regulations on being published in the *Gazette* shall have the force of law.

(4.) The Board may receive any grants, bequests, or gifts of books or specimens of any kind whatsoever for the use of the Institute, and dispose of them as it thinks fit.

(5.) The Board shall have control of the property from time to time vested in it or acquired by it; and shall make regulations for the management of the same, and for the encouragement of research by the members of the Institute; and in all matters, specified or unspecified, shall have power to act for and on behalf of the Institute.

7. (1.) Any casual vacancy in the Board, howsoever caused, shall be filled within three months by the society or authority that appointed the member whose place has become vacant, and if not filled within that time the vacancy shall be filled by the Board.

(2.) Any person appointed to fill a casual vacancy shall only hold office for such period as his predecessor would have held office under this Act.

8. (1.) Annual meetings of the Board shall be held in the month of January in each year, the date and place of such annual meeting to be fixed at the previous annual meeting.

(2.) The Board may meet during the year at such other times and places as it deems necessary.

(3.) At each annual meeting the President shall present to the meeting a report of the work of the Institute for the year preceding, and a balance-sheet, duly audited, of all sums received and paid on behalf of the Institute.

9. The Board may from time to time, as it sees fit, make arrangements for the holding of general meetings of members of the Institute,

at times and places to be arranged, for the reading of scientific papers, the delivery of lectures, and for the general promotion of science in New Zealand by any means that may appear desirable.

10. The Minister of Finance shall from time to time, without further appropriation than this Act, pay to the Board the sum of five hundred pounds in each financial year, to be applied in or towards payment of the general current expenses of the Institute.

11. Forthwith upon the making of any regulations or the publication of any Transactions, the Board shall transmit a copy thereof to the Minister of Internal Affairs, who shall lay the same before Parliament if sitting, or if not, then within twenty days after the commencement of the next ensuing session thereof.

SCHEDULE.

Enactments consolidated.

1903, No. 48.—The New Zealand Institute Act, 1903.

NEW ZEALAND INSTITUTE AMENDMENT ACT, 1920.

1920, No. 3.

AN ACT to amend the New Zealand Institute Act, 1908.

[*30th July, 1920.*

BE IT ENACTED by the General Assembly of New Zealand in Parliament assembled, and by the authority of the same, as follows :—

1. This Act may be cited as the New Zealand Institute Amendment Act, 1920, and shall be read together with and deemed part of the New Zealand Institute Act, 1908.

2. Section ten of the New Zealand Institute Act, 1908, is hereby amended by omitting the words "five hundred pounds," and substituting the words "one thousand pounds."

REGULATIONS.

THE following are the regulations of the New Zealand Institute under the Act of 1903 :—*

The word "Institute" used in the following regulations means the New Zealand Institute as constituted by the New Zealand Institute Act, 1903.

INCORPORATION OF SOCIETIES.

1. No society shall be incorporated with the Institute under the provisions of the New Zealand Institute Act, 1903, unless such society shall consist of not less than twenty-five members, subscribing in the aggregate a sum of not less than £25 sterling annually for the promotion of art, science, or such other branch of knowledge for which it is associated, to be from time to time certified to the satisfaction of the Board of Governors of the Institute by the President for the time being of the society.

2. Any society incorporated as aforesaid shall cease to be incorporated with the Institute in case the number of the members of the said society shall at any time become less than twenty-five, or the amount of money annually subscribed by such members shall at any time be less than £25.

3. The by-laws of every society to be incorporated as aforesaid shall provide for the expenditure of not less than one-third of the annual

* *New Zealand Gazette*, 14th July, 1904.

revenue in or towards the formation or support of some local public museum or library, or otherwise shall provide for the contribution of not less than one-sixth of its said revenue towards the extension and maintenance of the New Zealand Institute.

4. Any society incorporated as aforesaid which shall in any one year fail to expend the proportion of revenue specified in Regulation No. 3 aforesaid in manner provided shall from henceforth cease to be incorporated with the Institute.

Publications.

5. All papers read before any society for the time being incorporated with the Institute shall be deemed to be communications to the Institute, and then may be published as Proceedings or Transactions of the Institute, subject to the following regulations of the Board of the Institute regarding publications :—

(*a*.) The publications of the Institute shall consist of—

(1.) A current abstract of the proceedings of the societies for the time being incorporated with the Institute, to be intituled "Proceedings of the New Zealand Institute";

(2.) And of transactions comprising papers read before the incorporated societies (subject, however, to selection as hereinafter mentioned), and of such other matter as the Board of Governors shall from time to time determine to publish, to be intituled "Transactions of the New Zealand Institute."

(*b*.) The Board of Governors shall determine what papers are to be published.

(*c*.) Papers not recommended for publication may be returned to their authors if so desired.

(*d*.) All papers sent in for publication must be legibly written, typewritten, or printed.

(*e*.) A proportional contribution may be required from each society towards the cost of publishing Proceedings and Transactions of the Institute.

(*f*.) Each incorporated society will be entitled to receive a proportional number of copies of the Transactions and Proceedings of the New Zealand Institute, to be from time to time fixed by the Board of Governors.

Management of the Property of the Institute.

6. All property accumulated by or with funds derived from incorporated societies, and placed in charge of the Institute, shall be vested in the Institute, and be used and applied at the discretion of the Board of Governors for public advantage, in like manner with any other of the property of the Institute.

7. All donations by societies, public Departments, or private individuals to the Institute shall be acknowledged by a printed form of receipt and shall be entered in the books of the Institute provided for that purpose, and shall then be dealt with as the Board of Governors may direct.

Honorary Members.

8. The Board of Governors shall have power to elect honorary members (being persons not residing in the Colony of New Zealand), provided that the total number of honorary members shall not exceed thirty.

9. In case of a vacancy in the list of honorary members, each incorporated society, after intimation from the Secretary of the Institute, may nominate for election as honorary member one person.

10. The names, descriptions, and addresses of persons so nominated, together with the grounds on which their election as honorary members is recommended, shall be forthwith forwarded to the President of the New Zealand Institute, and shall by him be submitted to the Governors at the next succeeding meeting.

General Regulations.

11. Subject to the New Zealand Institute Act, 1908, and to the foregoing rules, all societies incorporated with the Institute shall be entitled to retain or alter their own form of constitution and the by-laws for their own management, and shall conduct their own affairs.

12. Upon application signed by the President and countersigned by the Secretary of any society, accompanied by the certificate required under Regulation No. 1, a certificate of incorporation will be granted under the seal of the Institute, and will remain in force as long as the foregoing regulations of the Institute are complied with by the society.

13. In voting on any subject the President is to have a deliberate as well as a casting vote.

14. The President may at any time call a meeting of the Board, and shall do so on the requisition in writing of four Governors.

15. Twenty-one days' notice of every meeting of the Board shall be given by posting the same to each Governor at an address furnished by him to the Secretary.

16. In case of a vacancy in the office of President, a meeting of the Board shall be called by the Secretary within twenty-one days to elect a new President.

17. The Governors for the time being resident or present in Wellington shall be a Standing Committee for the purpose of transacting urgent business and assisting the officers.

18. The Standing Committee may appoint persons to perform the duties of any other office which may become vacant. Any such appointment shall hold good until the next meeting of the Board, when the vacancy shall be filled.

19. The foregoing regulations may be altered or amended at any annual meeting, provided that notice be given in writing to the Secretary of the Institute not later than the 30th November.

The following additional regulations, and amendment to regulations, were adopted at a general meeting of the Board of Governors of the New Zealand Institute, held at Wellington on the 30th January, 1918, and at Christchurch on the 3rd February, 1919. (See *New Zealand Gazette*, No. 110, 4th September, 1919.)

Regulations governing the Fellowship of the Institute.

20. The Fellowship of the New Zealand Institute shall be an honorary distinction for the life of the holder.

21. The Original Fellows shall be twenty in number, and shall include the past Presidents and the Hutton and Hector Medallists who have held their distinctions and positions prior to 3rd February, 1919, and who at that date are members of the Institute. The remaining Original Fellows

shall be nominated as provided for in Regulation 26 (*a*), and shall be elected by the said past Presidents and Hector and Hutton Medallists.

22. The total number of Fellows at any time shall not be more than forty.

23. After the appointment and election of the Original Fellows, as provided in Regulation 21, not more than four Fellows shall be elected in any one year.

24. The Fellowship shall be given for research or distinction in science.

25. No person shall be elected as Fellow unless he is a British subject and has been a member of one of the incorporated societies for three years immediately preceding his election.

26. After the appointment and election of the Original Fellows as provided in Regulation 21 there shall be held an annual election of Fellows at such time as the Board of Governors shall appoint. Such election shall be determined as follows:—

(*a*.) Each of the incorporated societies at Auckland, Wellington, Christchurch, and Dunedin may nominate not more than twice as many persons as there are vacancies, and each of the other incorporated societies may nominate as many persons as there are vacancies. Each nomination must be accompanied by a statement of the qualifications of the candidate for Fellowship.

(*b*.) Out of the persons so nominated the Fellows resident in New Zealand shall select twice as many persons as there are vacancies, if so many be nominated.

(*c*.) The names of the nominees shall be submitted to the Fellows at least six months, and the names selected by them submitted to the Governors at least three months, before the date fixed for the annual meeting of the Board of Governors at which the election is to take place.

(*d*.) The election shall be made by the Board of Governors at the annual meeting from the persons selected by the Fellows.

(*e*.) The methods of selection in subclause (*b*) and of election in subclause (*d*) shall be determined by the Board of Governors.

(*f*.) The official abbreviation of the title "Fellow of the New Zealand Institute" shall be "F.N.Z.Inst."

Amendment to Regulations.

Regulation 5 (*a*) of the regulations published in the *New Zealand Gazette* of the 14th July, 1904, is hereby amended to read:—

"(*a*.) The publications of the Institute shall consist of—

"(1.) Such current abstract of the proceedings of the societies for the time being incorporated with the Institute as the Board of Governors deems desirable;

"(2.) And of transactions comprising papers read before the incorporated societies or any general meeting of the New Zealand Institute (subject, however, to selection as hereinafter mentioned), and of such other matter as the Board of Governors shall from time to time for special reasons in each case determine to publish, to be intituled *Transactions of the New Zealand Institute*."

THE HUTTON MEMORIAL MEDAL AND RESEARCH FUND.

Declaration of Trust.

This deed, made the fifteenth day of February, one thousand nine hundred and nine (1909), between the New Zealand Institute of the one part, and the Public Trustee of the other part: Whereas the New Zealand Institute is possessed of a fund consisting now of the sum of five hundred and fifty-five pounds one shilling (£555 1s.), held for the purposes of the Hutton Memorial Medal and Research Fund on the terms of the rules and regulations made by the Governors of the said Institute, a copy whereof is hereto annexed: And whereas the said money has been transferred to the Public Trustee for the purposes of investment, and the Public Trustee now holds the same for such purposes, and it is expedient to declare the trusts upon which the same is held by the Public Trustee:

Now this deed witnesseth that the Public Trustee shall hold the said moneys and all other moneys which shall be handed to him by the said Governors for the same purposes upon trust from time to time to invest the same upon such securities as are lawful for the Public Trustee to invest on, and to hold the principal and income thereof for the purposes set out in the said rules hereto attached.

And it is hereby declared that it shall be lawful for the Public Trustee to pay all or any of the said moneys, both principal and interest, to the Treasurer of the said New Zealand Institute upon being directed so to do by a resolution of the Governors of the said Institute, and a letter signed by the Secretary of the said Institute enclosing a copy of such resolution certified by him and by the President as correct shall be sufficient evidence to the Public Trustee of the due passing of such resolution: And upon receipt of such letter and copy the receipt of the Treasurer for the time being of the said Institute shall be a sufficient discharge to the Public Trustee: And in no case shall the Public Trustee be concerned to inquire into the administration of the said moneys by the Governors of the said Institute.

As witness the seals of the said parties hereto, the day and year hereinbefore written.

Resolutions of Board of Governors.

Resolved by the Board of Governors of the New Zealand Institute that—

1. The funds placed in the hands of the Board by the committee of subscribers to the Hutton Memorial Fund be called "The Hutton Memorial Research Fund," in memory of the late Captain Frederick Wollaston Hutton, F.R.S. Such fund shall consist of the moneys subscribed and granted for the purpose of the Hutton Memorial, and all other funds which may be given or granted for the same purpose.

2. The funds shall be vested in the Institute. The Board of Governors of the Institute shall have the control of the said moneys, and may invest the same upon any securities proper for trust-moneys.

3. A sum not exceeding £100 shall be expended in procuring a bronze medal to be known as "The Hutton Memorial Medal."

4. The fund, or such part thereof as shall not be used as aforesaid, shall be invested in such securities as aforesaid as may be approved of by the Board of Governors, and the interest arising from such investment shall be used for the furtherance of the objects of the fund.

5. The Hutton Memorial Medal shall be awarded from time to time by the Board of Governors, in accordance with these regulations, to persons who have made some noticeable contribution in connection with the zoology, botany, or geology of New Zealand.

6. The Board shall make regulations setting out the manner in which the funds shall be administered. Such regulations shall conform to the terms of the trust.

7. The Board of Governors may, in the manner prescribed in the regulations, make grants from time to time from the accrued interest to persons or committees who require assistance in prosecuting researches in the zoology, botany, or geology of New Zealand.

8. There shall be published annually in the *Transactions of the New Zealand Institute* the regulations adopted by the Board as aforesaid, a list of the recipients of the Hutton Memorial Medal, a list of the persons to whom grants have been made during the previous year, and also, where possible, an abstract of researches made by them.

Regulations under which the Hutton Memorial Medal shall be awarded and the Research Fund administered.

1. Unless in exceptional circumstances, the Hutton Memorial Medal shall be awarded not oftener than once in every three years; and in no case shall any medal be awarded unless, in the opinion of the Board, some contribution really deserving of the honour has been made.

2. The medal shall not be awarded for any research published previous to the 31st December, 1906.

3. The research for which the medal is awarded must have a distinct bearing on New Zealand zoology, botany, or geology.

4. The medal shall be awarded only to those who have received the greater part of their education in New Zealand or who have resided in New Zealand for not less than ten years.

5. Whenever possible, the medal shall be presented in some public manner.

6. The Board of Governors may, at any annual meeting, make grants from the accrued interest of the fund to any person, society, or committee for the encouragement of research in New Zealand zoology, botany, or geology.

7. Applications for such grants shall be made to the Board before the 30th September.

8. In making such grants the Board of Governors shall give preference to such persons as are defined in regulation 4.

9. The recipients of such grants shall report to the Board before the 31st December in the year following, showing in a general way how the grant has been expended and what progress has been made with the research.

10. The results of researches aided by grants from the fund shall, where possible, be published in New Zealand.

11. The Board of Governors may from time to time amend or alter the regulations, such amendments or alterations being in all cases in conformity with resolutions 1 to 4.

Award of the Hutton Memorial Medal.

1911. Professor W. B. Benham, D.Sc., F.R.S., University of Otago—For researches in New Zealand zoology.

1914. Dr. L. Cockayne, F.L.S., F.R.S.—For researches on the ecology of New Zealand plants.

1917. Professor P. Marshall, M.A., D.Sc.—For researches in New Zealand geology.

1920. Rev. John E. Holloway, D.Sc.—For researches in New Zealand pteridophytic botany.

Grant from the Hutton Memorial Research Fund.

1919. Miss M. K. Mestayer—£10, for work on the New Zealand Mollusca.

HECTOR MEMORIAL RESEARCH FUND.

Declaration of Trust.

This deed, made the thirty-first day of July, one thousand nine hundred and fourteen, between the New Zealand Institute, a body corporate duly incorporated by the New Zealand Institute Act, 1908, of the one part, and the Public Trustee of the other part: Whereas by a declaration of trust dated the twenty-seventh day of January, one thousand nine hundred and twelve, after reciting that the New Zealand Institute was possessed of a fund consisting of the sum of £1,045 10s. 2d., held for the purposes of the Hector Memorial Research Fund on the terms of the rules and regulations therein mentioned, which said moneys had been handed to the Public Trustee for investment, it was declared (*inter alia*) that the Public Trustee should hold the said moneys and all other moneys which should be handed to him by the said Governors of the Institute for the same purpose upon trust from time to time, to invest the same in the common fund of the Public Trust Office, and to hold the principal and income thereof for the purposes set out in the said rules and regulations in the said deed set forth: And whereas the said rules and regulations have been amended by the Governors of the New Zealand Institute, and as amended are hereinafter set forth: And whereas it is expedient to declare that the said moneys are held by the Public Trustee upon the trusts declared by the said deed of trust and for the purposes set forth in the said rules and regulations as amended as aforesaid:

Now this deed witnesseth and it is hereby declared that the Public Trustee shall hold the said moneys and all other moneys which shall be handed to him by the said Governors for the same purpose upon trust from time to time to invest the same in the common fund of the Public Trust Office, and to hold the principal and income thereof for the purposes set out in the said rules and regulations hereinafter set forth:

And it is hereby declared that it shall be lawful for the Public Trustee to pay, and he shall pay, all or any of the said moneys, both principal and interest, to the Treasurer of the said New Zealand Institute upon being directed to do so by a resolution of the Governors of the said Institute, and a letter signed by the Secretary of the said Institute enclosing a copy of such resolution certified by him and by the President as correct shall be sufficient evidence to the Public Trustee of the due passing of such resolution: And upon receipt of such letter and copy the receipt of the Treasurer for the time being of the said Institute shall be a sufficient discharge to the Public Trustee: And in

no case shall the Public Trustee be concerned to inquire into the administration of the said moneys by the Governors of the said Institute.

As witness the seals of the said parties hereto, the day and year first hereinbefore written.

Rules and Regulations made by the Governors of the New Zealand Institute in relation to the Hector Memorial Research Fund.

1. The funds placed in the hands of the Board by the Wellington Hector Memorial Committee be called "The Hector Memorial Research Fund," in memory of the late Sir James Hector, K.C.M.G., F.R.S. The object of such fund shall be the encouragement of scientific research in New Zealand, and such fund shall consist of the moneys subscribed and granted for the purpose of the memorial and all other funds which may be given or granted for the same purpose.

2. The funds shall be vested in the Institute. The Board of Governors of the said Institute shall have the control of the said moneys, and may invest the same upon any securities proper for trust-moneys.

3. A sum not exceeding one hundred pounds (£100) shall be expended in procuring a bronze medal, to be known as the Hector Memorial Medal.

4. The fund, or such part thereof as shall not be used as aforesaid, shall be invested in such securities as may be approved by the Board of Governors, and the interest arising from such investment shall be used for the furtherance of the objects of the fund by providing thereout a prize for the encouragement of such scientific research in New Zealand of such amount as the Board of Governors shall from time to time determine.

5. The Hector Memorial Medal and Prize shall be awarded annually by the Board of Governors.

6. The prize and medal shall be awarded by rotation for the following subjects, namely—(1) Botany, (2) chemistry, (3) ethnology, (4) geology, (5) physics (including mathematics and astronomy), (6) zoology (including animal physiology).

In each year the medal and prize shall be awarded to that investigator who, working within the Dominion of New Zealand, shall in the opinion of the Board of Governors have done most towards the advancement of that branch of science to which the medal and prize are in such year allotted.

7. Whenever possible the medal shall be presented in some public manner.

AWARD OF THE HECTOR MEMORIAL RESEARCH FUND.

1912. L. Cockayne, Ph.D., F.L.S., F.R.S.—For researches in New Zealand botany.
1913. T. H. Easterfield, M.A., Ph.D.—For researches in chemistry.
1914. Elsdon Best—For researches in New Zealand ethnology.
1915. P. Marshall, M.A., D.Sc., F.G.S.—For researches in New Zealand geology.
1916. Sir Ernest Rutherford, F.R.S.—For researches in physics.
1917. Charles Chilton, M.A., D.Sc., F.L.S., C.M.Z.S.—For researches in zoology.
1918. T. F. Cheeseman, F.L.S., F.Z.S.—For researches in New Zealand systematic botany.
1919. P. W. Robertson—For researches in chemistry.
1920. S. Percy Smith—For researches in New Zealand ethnology.
1921. R. Speight, M.A., M.Sc., F.G.S.—For work in New Zealand geology.
1922. C. Coleridge Farr, D.Sc.—For research in physical science, and more particularly work in connection with the magnetic survey of New Zealand.

REGULATIONS FOR ADMINISTERING THE GOVERNMENT RESEARCH GRANT.*

All grants shall be subject to the following conditions, and each grantee shall be duly informed of these conditions :—

1. All instruments, specimens, objects, or materials of permanent value, whether purchased or obtained out of or by means of the grant, or supplied from among those at the disposal of the Institute, are to be regarded, unless the Research Grants Committee decide otherwise, as the property of the Institute, and are to be returned by the grantee, for disposal according to the orders of the committee, at the conclusion of his research, or at such other time as the committee may determine.

2. Every one receiving a grant shall furnish to the Research Grants Committee, on or before the 1st January following upon the allotment of the grant, a report (or, if the object of the grant be not attained, an interim report, to be renewed at the same date in each subsequent year until a final report can be furnished or the committee dispense with further reports), containing (*a*) a brief statement showing the results arrived at or the stage which the inquiry has reached; (*b*) a general statement of the expenditure incurred, accompanied, as far as is possible, with vouchers; (*c*) a list of the instruments, specimens, objects, or materials purchased or obtained out of the grant, or supplied by the committee, which are at present in his possession; and (*d*) references to any transactions, journals, or other publications in which results of the research have been printed. In the event of the grantee failing to send in within three months of the said 1st January a report satisfactory to the committee he may be required, on resolution of the Board of Governors, to return the whole of the sum allotted to him.

3. Where a grant is made to two or more persons acting as a committee for the purpose of carrying out some research, one member of the said committee shall assume the responsibility of furnishing the report and receiving and disbursing the money.

4. Papers in which results are published that have been obtained through aid furnished by the Government grant should contain an acknowledgment of that fact.

5. Every grantee shall, before any of the grant is paid to him, be required to sign an engagement that he is prepared to carry out the general conditions applicable to all grants, as well as any conditions which may be attached to his particular grant.

6. In cases where specimens or preparations of permanent value are obtained through a grant the committee shall, as far as possible, direct that such specimens shall be deposited in a museum or University college within the province where the specimens or material were obtained, or in which the grantee has worked. The acknowledgment of the receipt of the specimens by such institution shall fully satisfy the claims of the Institute.

7. In cases where, after completion of a research, the committee directs that any instrument or apparatus obtained by means of the grant shall be deposited in an institution of higher learning, such deposit shall be subject to an annual report from the institution in question as to the condition of the instrument or apparatus, and as to the use that has been made of it.

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* In addition to these regulations the Standing Committee is also bound by certain resolutions which appear on page 536 of volume 49, *Trans. N.Z. Inst.*, and which grantees are also bound to observe.

RESEARCH GRANTS MADE DURING THE YEAR ENDING 31ST MARCH, 1922.

Through the Auckland Institute :—

Professor P. W. Burbidge, £100 for research in wireless telegraphy.

Through the Philosophical Institute of Canterbury :—

Mr. A. M. Wright, £75 for research in vitamines content of commercial meat products.

Through the Nelson Institute :—

Mr. William C. Davies, £50 for research in soil protozoa.
Professor T. H. Easterfield, £200 for research in orchard fruits.
Mr. D. D. Milligan, £50 for research in New Zealand Orthoptera.

THE CARTER BEQUEST.

FOR extracts from the will of Charles Rooking Carter see vol. 48, 1916, pp. 565–66.

NEW ZEALAND INSTITUTE.

ESTABLISHED UNDER AN ACT OF THE GENERAL ASSEMBLY OF NEW ZEALAND INTITULED THE NEW ZEALAND INSTITUTE ACT, 1867; RECONSTITUTED BY AN ACT OF THE GENERAL ASSEMBLY OF NEW ZEALAND UNDER THE NEW ZEALAND INSTITUTE ACT, 1903, AND CONTINUED BY THE NEW ZEALAND INSTITUTE ACT, 1908.

BOARD OF GOVERNORS.

EX OFFICIO.

His Excellency the Governor-General.
The Hon. the Minister of Internal Affairs.

NOMINATED BY THE GOVERNMENT.

Dr. Charles Chilton, F.L.S., C.M.Z.S., F.N.Z.Inst. (reappointed December, 1918); Dr. J. Allan Thomson, F.G.S., F.N.Z.Inst. (reappointed December, 1919); Mr. B. C. Aston, F.I.C., F.C.S., F.N.Z.Inst. (reappointed December, 1919); Dr. Leonard Cockayne, F.R.S., F.L.S., F.N.Z.Inst. (appointed June, 1921).

ELECTED BY AFFILIATED SOCIETIES (DECEMBER, 1921).

Wellington Philosophical Institute ...	Professor E. Marsden, D.Sc., F.N.Z.Inst. Professor C. A. Cotton, D.Sc., F.G.S., F.N.Z.Inst.
Auckland Institute	Professor H. W. Segar, M.A., Ph.D., F.N.Z.Inst. Professor F. P. Worley, D.Sc.
Philosophical Institute of Canterbury ...	Professor C. Coleridge Farr, D.Sc., F.P.S.L., F.N.Z.Inst. Mr. A. M. Wright, F.C.S.
Otago Institute	Hon. G. M. Thomson, F.L.S., F.N.Z.Inst., M.L.C. Mr. W. G. Howes, F.E.S.
Hawke's Bay Philosophical Institute ..	Mr. Thomas Hyde.
Nelson Institute	Dr. R. J. Tillyard, M.A., Sc.D., F.L.S., F.E.S.
Manawatu Philosophical Society ...	Mr. M. A. Eliott.
Wanganui Philosophical Society ..	Dr. P. Marshall, M.A., F.G.S., F.N.Z.Inst.
Poverty Bay Institute	Ven. Archdeacon H. W. Williams, M.A.

OFFICERS FOR THE YEAR 1922.

PRESIDENT: Professor H. B. Kirk, M.A., F.N.Z.Inst.
HON. TREASURER: Mr. M. A. Eliott.
HON. EDITOR: Mr. Johannes C. Andersen.
HON. LIBRARIAN: Dr. J. Allan Thomson, F.G.S., F.N.Z.Inst.
HON. SECRETARY: Mr. B. C. Aston, F.I.C., F.C.S., F.N.Z.Inst.
(Box 40, Post-office, Wellington).

AFFILIATED SOCIETIES.

Name of Society.	Secretary's Name and Address.	Date of Affiliation.
Wellington Philosophical Society	E. K. Lomas, Training College, Wellington	10th June, 1868.
Auckland Institute ..	T. F. Cheeseman, Museum, Auckland	10th June, 1868.
Philosophical Institute of Canterbury	G. E. Archey, Canterbury Museum, Christchurch	22nd October, 1868.
Otago Institute	Wm. Martin, 21 Musselburgh Rise, Dunedin	18th October, 1869.
Hawke's Bay Philosophical Institute	C. F. H. Pollock, P.O. Box 301, Napier	31st March, 1875.
Nelson Institute	Mrs. Margaret Graham, Nelson	20th December, 1883.
Manawatu Philosophical Society	Chas. T. Salmon, P.O. Box 293, Palmerston North	6th January, 1905.
Wanganui Philosophical Society	R. Murdoch, P.O. Box 221, Wanganui	2nd December, 1911.
Poverty Bay Institute ..	John Mouat, Adams Chambers, Gladstone Road, Gisborne	1st February, 1919.

FORMER HONORARY MEMBERS.

1870.

Agassiz, Professor Louis.
Drury, Captain Byron, R.N.
Finsch, Professor Otto, Ph.D.
Flower, Professor W. H., F.R.S.
Hochstetter, Dr. Ferdinand von.
Hooker, Sir J. D., G.C.S.I., C.B., M.D., F.R.S., O.M.
Mueller, Ferdinand von, M.D., F.R.S., C.M.G.
Owen, Professor Richard, F.R.S.
Richards, Rear-Admiral G. H.

1871.

Darwin, Charles, M.A., F.R.S.
Gray, J. E., Ph.D., F.R.S.
Lindsay, W. Lauder, M.D., F.R.S.E.

1872.

Grey, Sir George, K.C.B.
Huxley, Thomas H., LL.D., F.R.S.
Stokes, Vice-Admiral J. L.

1873.

Bowen, Sir George Ferguson, G.C.M.G.
Günther, A., M.D., M.A., Ph.D., F.R.S.
Lyell, Sir Charles, Bart., D.C.L., F.R.S.
Pickard-Cambridge, Rev. O., M.A., F.R.S., C.M.Z.S.

1874.

McLachlan, Robert, F.L.S.
Newton, Alfred, F.R.S.
Thomson, Professor Wyville, F.R.S.

1875.

Filhol, Dr. H.
Rolleston, Professor G., M.D., F.R.S.
Sclater, P. L., M.A., Ph.D., F.R.S.

1876.

Berggren, Dr. S.
Clarke, Rev. W. B., M.A., F.R.S.
Etheridge, Professor R., F.R.S.

1877.

Baird, Professor Spencer F.
Sharp, Dr. D.
Weld, Frederick A., C.M.G.

1878.

Garrod, Professor A. H., F.R.S.
Müller, Professor Max, F.R.S.
Tenison-Woods, Rev. J. E., F.L.S.

1880.

The Most Noble the Marquis of Normanby, G.C.M.G.

1883.

Carpenter, Dr. W. B., C.B., F.R.S.
Ellery, Robert L. J., F.R.S.
Thomson, Sir William, F.R.S.

1885.

Gray, Professor Asa.
Sharp, Richard Bowdler, M.A., F.R.S.
Wallace, Sir A. R., F.R.S., O.M.

1888.

Beneden, Professor J. P. van.
Ettingshausen, Baron von.
McCoy, Professor Sir F., K.C.M.G., D.Sc., F.R.S.

1890.

Riley, Professor C. V.

1891.

Davis, J. W., F.G.S., F.L.S.

1895.

Mitten, William, F.R.S.

1896.

Langley, S. P.
Lydekker, Richard, F.R.S.

1900.

Agardh, Dr. J. G.
Avebury, Lord, P.C., F.R.S.
Massee, George, F.L.S., F.R.M.S.

1901.

Eve, H. W., M.A.
Howes, G. B., LL.D., F.R.S.

1906.

Milne, J., F.R.S.

1909.

Darwin, Sir George, F.R.S.

1910.

Bruce, Dr. W. S.

1914.

Arber, E. A. Newell, M.A., Sc.D., F.G.S., F.L.S.

FORMER MANAGER AND EDITOR.

[Under the New Zealand Institute Act, 1867.]

1867–1903.

Hector, Sir James, M.D., K.C.M.G., F.R.S.

PAST PRESIDENTS.

1903–4.

Hutton, Captain Frederick Wollaston, F.R.S.

1905–6.

Hector, Sir James, M.D. K.C.M.G., F.R.S.

1907–8.

Thomson, George Malcolm, F.L.S.

1909–10.

Hamilton, A.

1911–12.

Cheeseman, T. F., F.L.S., F.Z.S.

1913–14.

Chilton, C., M.A., D.Sc., LL.D., F.L.S., C.M.Z.S.

1915.

Petrie, D., M.A., Ph.D.

1916–17.

Benham, W. B., M.A., D.Sc., F.Z.S., F.R.S.

1918–19.

Cockayne, L., Ph.D., F.R.S., F.L.S., F.N.Z.Inst.

1920–21.

Easterfield, T. H., M.A., Ph.D., F.N.Z.Inst.

HONORARY MEMBERS.

1890.

Liversidge, Professor A., M.A., F.R.S., Fieldhead, Coombe Warren, Kingston Hill, England.

Nordstedt, Professor Otto, Ph.D., University of Lund, Sweden.

1891.

Goodale, Professor G. L., M.D., LL.D., Harvard University, Cambridge, Mass., U.S.A.

1894.

Codrington, Rev. R. H., D.D., Wadhurst Rectory, Sussex, England.

Thiselton-Dyer, Sir W. T., K.C.M.G., C.I.E., LL.D., M.A., F.R.S., Witcombe, Gloucester, England.

1901.

Goebel, Professor Dr. Carl von, University of Munich.

1902.

Sars, Professor G. O., University of Christiania, Norway.

1903.

Klotz, Professor Otto J., 437 Albert Street, Ottawa, Canada.

1904.

Rutherford, Professor Sir E., D.Sc., F.R.S. F.N.Z.Inst., Nobel Laureate, Cambridge, England.

David, Professor T. Edgeworth, F.R.S., C.M.G., Sydney University, N.S.W.

1906.

Beddard, F. E., D.Sc., F.R.S., Zoological Society, London.

Brady, G. S., D.Sc., F.R.S., University of Durham, England.

1907.

Dendy, Dr. A., F.R.S., King's College, University of London, England.
Diels, Professor L., Ph.D., University of Marburg.
Meyrick, E., B.A., F.R.S., Marlborough College, England.
Stebbing, Rev. T. R. R., F.R.S., Tunbridge Wells, England.

1913.

Davis, Professor W. Morris, Harvard University, Cambridge, Mass., U.S.A.
Hemsley, Dr. W. Botting, F.R.S., Kew Lodge, St. Peter's Road, Broadstairs, Kent, England.

1914.

Balfour, Professor I. Bayley, F.R.S., Royal Botanic Gardens, Edinburgh.
Haswell, Professor W. A., F.R.S, Mimihau, Woollahra Point, Sydney.

1915.

Bateson, Professor W., F.R.S., Merton, Surrey, England.

1916.

Massart, Professor Jean, University of Brussels, Belgium.

1919.

Mellor, Joseph William, D.Sc. (N.Z.), Sandon House, Regent Street, Stoke-on-Trent, England.

1920.

Fraser, Sir J. G., D.C.L., No. 1 Brick Court, Temple, London, E.C. 4.
Gregory, Professor J. W., D.Sc., F.R.S., F.G.S., University, Glasgow.
Hall, Sir A. D., M.A., K.C.B., F.R.S., Ministry of Agriculture, London.
Mawson, Sir Douglas, B.E., D.Sc., The University, Box 498, G.P.O., Adelaide.
Woods, Henry, M.A., F.R.S., F.G.S., University, Cambridge.

ORIGINAL FELLOWS OF THE NEW ZEALAND INSTITUTE.

(See *New Zealand Gazette*, 20th November, 1919.)

Aston, Bernard Cracroft, F.I.C., F.C.S.
*‡Benham, Professor William Blaxland, M.A., D.Sc., F.R.S., F.Z.S.
†Best, Elsdon.
*†Cheeseman, Thomas Frederick, F.L.S., F.Z.S.
*†Chilton, Professor Charles, M.A., D.Sc., LL.D., M.B., C.M., F.L.S., C.M.Z.S.
*†‡Cockayne, Leonard, Ph.D., F.R.S., F.L.S.
†Easterfield, Professor Thomas Hill, M.A., Ph.D., F.I.C., F.C.S.
Farr, Professor Clinton Coleridge, D.Sc., F.P.S.L., Assoc.M.Inst.C.E.
Hogben, George, C.M.G., M.A., F.G.S.
Hudson, George Vernon, F.E.S.
Kirk, Professor Harry Borrer, M.A.
†‡Marshall, Patrick, M.A., D.Sc., F.G.S., F.R.G.S., F.E.S.
*Petrie, Donald, M.A., Ph.D.
†Rutherford, Sir Ernest, Kt., F.R.S., D.Sc., Ph.D., LL.D.
Segar, Professor Hugh William, M.A.
Smith, Stephenson Percy, F.R.G.S.
Speight, Robert, M.A., M.Sc., F.G.S.
Thomas, Professor Algernon Phillips Withiel, M.A., F.L.S.
*Thomson, Hon. George Malcolm, F.L.S., M.L.C.
Thomson, James Allan, M.A., D.Sc., A.O.S.M., F.G.S.

FELLOWS ELECTED, 1921.

Cotton, Charles Andrew, D.Sc., A.O.S.M., F.G.S.
Hilgendorf, Frederick William, B.A., D.Sc.
Holloway, Rev. John Ernest, L.Th., D.Sc.
Park, Professor James, M.Am.Inst.M.E., M.Inst.M.M., F.G.S.

FELLOWS ELECTED, 1922.

Laing, Robert Malcolm, M.A., B.Sc.
Marsden, Ernest, D.Sc., F.R.A.S.
Morgan, Percy Gates, M.A., F.G.S., A.O.S.M.
Sommerville, Duncan McLaren Young, M.A., D.Sc., F.R.S.E.

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* Past President. † Hector Medallist. ‡ Hutton Medallist.

ORDINARY MEMBERS.

WELLINGTON PHILOSOPHICAL SOCIETY.

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Ward, J. T., Victoria Avenue, Wanganui.*
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Blair, James, Kaiti.
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Ward, Rev. E., Waerengaahika.
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Williams, Ven. Archdeacon H. W., Naurea, Patutahi.
Wilson, Rev. G. D., Te Karaka.

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Auckland University : *Calendar.*
Geological Survey : *Bulletins.*
Houses of Parliament : *Journals* and *Appendix.*
Journal of Agriculture.
Journal of Science and Technology.
New Zealand Employers' Federation : *Industrial Bulletin.*
New Zealand Official Year-book.
Polynesian Society : *Journal.*
Statistics of New Zealand.

Australia.

Au tralasian Association for the Advancement of Science : *Report.*
Australasian Institute of Mining Engineers : *Proceedings.*
Australian Antarctic Expedition, 1911–14 : *Reports.*
Australian Forestry Journal.
Commonwealth of Australia, Fisheries : *Parliamentary Report.*

New South Wales.

Agricultural Department, N.S.W. : *Agricultural Gazette.*
Australian Museum, Sydney : *Records ; Annual Report.*
Botanic Gardens and Government Domains, N.S.W. : *Report.*
Critical Revision of the Genus Eucalyptus.
Linnean Society of N.S.W. : *Proceedings.*
Northern Engineering Institute of N.S.W. : *Papers.*
Public Health Department, N.S.W. : *Annual Report.*

Queensland.

Geological Survey of Queensland : *Publications.*
Queensland Naturalist.
Royal Geographical Society : *Journal.*
Royal Society of Queensland : *Proceedings.*

South Australia.

Adelaide Chamber of Commerce : *Annual Report.*
Department of Chemistry, South Australia : *Bulletins.*
Mines Department and Geological Survey of South Australia : *Mining Operations ; G.S. Bulletins and Reports ; Metallurgical Reports ; Synopsis of Mining Laws.*
Public Library, Museum, and Art Gallery of South Australia : *Annual Report.*
Royal Society of South Australia : *Transactions and Proceedings.*

Tasmania.

Royal Society of Tasmania : *Papers and Proceedings.*

Victoria.

Advisory Committee: *Report on Brown Coal.*
Department of Agriculture: *Journal.*
Field Naturalists' Club of Victoria: *Victorian Naturalist.*
Mines Department and Geological Survey of Victoria: *Annual Report; Bulletins; Records.*
Public Library, Museum, and National Art Gallery of Victoria: *Annual Report.*
Royal Society of Victoria: *Proceedings.*

Western Australia.

Geological Survey of Western Australia: *Bulletins.*
Royal Society of Western Australia: *Journal and Proceedings.*

United Kingdom.

Board of Agriculture and Fisheries: *Fishery Investigations.*
Botanical Society of Edinburgh: *Transactions and Proceedings.*
British Association for the Advancement of Science: *Report.*
British Astronomical Association: *Journal; Memoirs; List of Members.*
British Museum: *Catalogues; Guides; Scientific Reports of British Antarctic Expedition, 1910.*
Cambridge Philosophical Society: *Proceedings.*
Cambridge University Library: *Report.*
Department of Scientific and Industrial Research: *Reports.*
Dove Marine Library: *Report.*
Geological Society, London: *Quarterly Journal.*
Geological Survey of Great Britain: *Summary of Progress.*
Handbooks, Commercial Towns, England.
Imperial Institute: *Bulletins.*
Institution of Civil Engineers: *Report.*
Leeds Philosophical and Literary Society: *Annual Report.*
Linnean Society: *Journal* (Botany); *Proceedings; List of Members.*
Liverpool Biological Society: *Proceedings.*
Liverpool Geological Society: *Proceedings.*
Marine Biological Association: *Journal.*
Marlborough College Natural History Society: *Reports.*
Mercantile Guardian, London.
Mineralogical Society: *Mineralogical Magazine.*
North of England Institute of Mining and Mechanical Engineers: *Transactions; Annual Report.*
Oxford University: *Calendar.*
Royal Anthropological Institute of Great Britain: *Journal.*
Royal Botanic Gardens, Edinburgh: *Notes.*
Royal Colonial Institute: *United Empire.*
Royal Geographical Society: *Geographical Journal.*
Royal Philosophical Society of Glasgow: *Proceedings.*
Royal Physical Society of Edinburgh: *Proceedings.*
Royal Scottish Geographical Society: *Scottish Geographical Magazine.*
Royal Society, Dublin: *Economic Proceedings.*
Royal Society of Edinburgh: *Proceedings; Transactions.*
Royal Society, London: *Proceedings* (Series A, B); *Phil. Trans.* (Series A, B); *Year-book.*

Royal Society of Literature : *Transactions.*
Royal Statistical Society, London : *Journal.*
Victoria Institute, London : *Journal of Transactions.*
Zoological Society of London : *Proceedings and Transactions.*

Austria.

K.K. Central Anstalt für Meteorologie und Erdkunde, Vienna.
K.K. Geologischen Reichlanstalt, Vienna : *Verhandl; Jahrb.*
K.K. Naturhistorischen Hofmuseums, Vienna : *Annalen.*
K.K. Zoologisch-Botanische Gesellschaft, Vienna : *Verhandl.*

Belgium.

Académie Royale de Belgique : *Bulletins.*
Librairie Nationale d'Art et d'Histoire : *Les Cahiers belges.*
Société Royale de Botanique de Belgique : *Bulletins.*
Société Royale Zoologique et Malacologique de Belgique : *Annales.*

Denmark.

Acad. Roy. de Sciences et de Lettres de Denmark : *Fordhandlinger ; Memoires.*
Dansk. Naturh. Foren., Kjöbenhavn : *Videnskabelige Meddelelser.*
Kong. Dansk. Videnskab. Selskab. : *Forhandlinger ; Skrifter.*
Zoological Museum, Copenhagen : *Danish-Ingolf Expedition.*

Finland.

Academia Aboensis, Abo : *Humaniora.*
Finska Vetenskaps-Societeten : *Acta ; Ofersigt ; Bidrag.*

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L'Observatoire Météorologique, Paris : *Annales.*
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Société Astronomique France : *Bulletin.*
Société de Chimie Industrielle, Paris : *Chimie et industries.*
Société de Géographie : *La Géographie.*
Société Zoologique de France : *Bulletin.*

Germany.

Botanische Verein der Provinz Brandenburg : *Verhandl.*
Konigl. Zool. u. Anthro.-Ethno. Museum, Dresden.
K.K. Zentral-Anstalt für Meteorologie und Geodynamik : *Jahrb.*
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Senkenbergische Naturforschende Gesellschaft, Frankfurt-am-Main : *Berichte.*
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Holland and Dutch East Indies.

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Koninklijke Naturkundige Vereeniging in Nederlandsch-Inde.
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Nederlandsche Entomologische Vereeniging : *Tydschrift.*
Rijks Ethnographisch Museum, Leiden : *Verslag.*

Italy.

Giornale Botanico Italiano, Nuevo.
Reale Società Geographica, Roma : *Bollettino.*
Revista Geographica Italiana.
Società Africana d'Italia : *Bollettino.*
Societa Botanica Italliana, Firenze : *Bollettino.*
Società Toscana di Scienze Naturali, Pisa : *Processi verbali.*

Norway.

Bergens Museum : *Aarbok ; Aarberetning.*
Norwegian Meteorologischen Instituts, Kristiana : *Jahrb.*

Spain.

Junta de Ciences Naturals de Barcelona : *Series botanica, geologica.*

Sweden.

Botaniska Notiser, Lund.
Kungl Svenska Vetenskapademiens, *Arkiv* for
Meteorologiske Iakttealser i Sverige.
Sverigeo Geologiska-Undersokning : *Arsbok.*

Switzerland.

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Naturforschende Gesellschaft, Bern : *Mittheilungen.*
Societa Elvetica delle Scienze Naturali, Bern : *Atti.*
Société de Physique et d'Histoire Naturelle de Geneve.

India and Ceylon.

Agricultural Department, Calcutta : *Report on Progress of Agriculture.*
Agricultural Research Institute and College, Pusa : *Report.*
Asiatic Society of Bengal, Calcutta.
Board of Scientific Advice : *Annual Report.*
Colombo Museum ; *Spolia Zeylanica.*
Geological Survey of India : *Records and Memoirs.*

Japan.

Icones Plantarum Formosanarum, Yaihoku.
Imperial Earthquake Investigation Committee, Tokyo : *Bulletin.*
Imperial University of Tokyo : *Journal of the College of Science.*
Tohoku Imperial University, Sendai : *Science Reports.*

Malay States.

Java Ethnographischen Reichsmuseums : *Katalog.*
Malay States Government Gazette.

Africa.

Durban Museum, Natal: *Annals.*
Natal Museum, Pietermaritzburg: *Annals.*
South African Association for the Advancement of Science: *South African Journal of Science.*
South African Museum: *Annals.*
Transvaal Museum: *Annals.*

Canada.

Department of Naval Service: *Annual Report; Tide Tables.*
Department of the Interior: *Dominion Observatory Reports.*
Mines Department, Geological Survey Branch: *Memoirs; Summary Report; Museum Bulletin.*
Mines Department, Mines Branch: *Bulletins; Annual Report;* other publications.
Nova Scotian Institute of Science, Halifax: *Proceedings.*
Royal Canadian Institute, Toronto: *Transactions.*
Royal Society, Canada: *Proceedings and Transactions.*

United States.

Academy of Natural Sciences, Philadelphia: *Proceedings.*
American Academy of Arts and Sciences: *Proceedings.*
American Geographical Society, New York: *Geographical Review.*
American Institute of Mining Engineers: *Transactions.*
American Journal of Philology.
American Museum of Natural History, New York: *Bulletins*
American Philosophical Society: *Proceedings.*
Arnold Arboretum of Harvard University: *Journal.*
Astronomical Society of the Pacific.
Astrophysical Journal.
Boston Society of Natural History: *Proceedings, Memoirs, &c.*
Brooklyn Institute of Arts and Sciences: *Bulletins.*
Buffalo Society of Natural Sciences: *Bulletin.*
Californian Academy of Sciences: *Proceedings.*
Chicago University: *Journal of Geology.*
Connecticut Academy of Arts and Sciences: *Transactions; Memoirs.*
Cornell University Agricultural Station: *Memoirs; Bulletins.*
Department of Registration and Education, State of Illinois: *Bulletin.*
Field Museum of Natural History, Chicago.
Franklin Institute: *Journal.*
Industrial and Engineering Chemistry: *Journal.*
Johns Hopkins University, Baltimore: *Studies; Circulars; Journal.*
Journal of Geology, Chicago.
Leland Stanford Junior University: *Publications.*
Library of Congress, Washington: *Report.*
Lick Observatory, University of California.
Lloyd Library, Ohio: *Index.*
Maryland Geological Survey: *Reports.*
Minnesota University and Geological Survey: *Agricultural Experiment Station Bulletin.*
Missouri Botanical Gardens: *Annals.*
Missouri Bureau of Geology and Mines: *Reports.*

Museum of Comparative Zoology, Harvard: *Bulletin; Annual Report; Memoirs.*
Mycological Notes, Cincinnati.
National Academy of Sciences: *Proceedings.*
New York Academy of Sciences: *Annals.*
Ohio Journal of Science.
Ohio State University: *Bulletin.*
Rochester Academy of Sciences: *Proceedings.*
Smithsonian Institution and U.S. National Museum: *Annual Report; Miscellaneous Collections; Contributions to Knowledge; Bulletins; Contributions from U.S. National Herbarium.*
Tufts College: *Studies (Scientific Series).*
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U.S. Department of Agriculture, Bureau of Biological Survey: *North American Fauna; Bulletins.*
U.S. Geological Survey: *Annual Report; Professional Papers; Mineral Resources; Bulletins; Water-supply Papers.*
U.S. National Research Council: *Bulletins.*
United States Naval Observatory: *Annual Report.*
University of California: *Bulletin of Department of Geology.*
Wagner Free Institute of Science: *Transactions.*
Wisconsin Academy of Sciences: *Transactions.*

Argentine.

Academia Nacional de Ciencias: *Boletin.*

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Da Escola Agricultura Rio de Janeiro.
Museo Nacional Rio de Janiero: *Archives.*
Observatorio de Rio de Janeiro.

Mexico.

Instituto Geologico de Mexico: *Anales.*

Peru.

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Geological Magazine, London.
Geological Society, Synod Hall, Castle Terrace, Edinburgh.
" London.
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High Commissioner for New Zealand, London.
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Institute of Jamaica, Kingston, Jamaica.
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Library, Advisory Research Council, Ottawa, Canada.
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Colombo Museum, Ceylon.
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Raffles Museum, Singapore.

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Queensland Museum, Brisbane.
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Australasian Association for the Advancement of Science, Sydney.
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Department of Mines, Sydney.
Engineering Association of New South Wales, Sydney.
Engineering Institute of New South Wales, Watt Street, Newcastle.
Library, Botanic Gardens, Sydney.
Linnean Society of New South Wales, Sydney.
Public Library, Sydney.
Royal Society of New South Wales, Sydney.
University Library, Sydney.

Victoria.

Advisory Council of Science and Industry, 314 Albert Street, East Melbourne.
Australian Institute of Mining Engineers, Melbourne.
Commonwealth Institute of Science and Industry, Danks Buildings, 391 Bourke Street, Melbourne.
Field Naturalists' Club, Melbourne.
Geological Survey of Victoria, Melbourne.
Legislative Library, Melbourne.
National Herbarium of Victoria, South Yarra
National Museum, Melbourne.
Royal Society of Victoria, Melbourne.
University Library, Melbourne.

Tasmania.

Public Library of Tasmania, Hobart.
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South Australia.

Public Museum and Art Gallery of South Australia, Adelaide.
Royal Society of South Australia, Adelaide.
University Library, Adelaide.

Western Australia.

Government Geologist, Perth.

Russia.

Emperor Peter I Agricultural Institute, Woronesh.
Imper. Moskofskoie Obshchestvo Iestestvo - Ispytatelei (Imperial Moscow Society of Naturalists).
Kiefskoie Obshchestvo Iestestvo-Ispytatelei (Kief Society of Naturalists).

Norway.

Adviser of Norwegian Fisheries, Bergen.
Bergens Museum, Bergen.
University of Christiania.

Sweden.

Geological Survey of Sweden, Stockholm.
Royal Academy of Science, Stockholm.
Universitetsbiblioteket, Uppsala.

Denmark.

Natural History Society of Copenhagen.
Royal Danish Academy of Sciences and Literature of Copenhagen.

Germany.

Biologisches Zentralblatt, Berlin, Dahlem.
Botanischer Verein der Provinz Brandenburg, Berlin.
Königliche Physikalisch-Oekonomische Gesellschaft, Königsberg, E. Prussia.
Königliches Zoologisches und Anthropologisch - Ethnographisches Museum, Dresden.
Naturhistorischer Verein, Bonn.
Naturhistorischer Museum, Hamburg.
Naturwissenschaftlicher Verein, Bremen.
Naturwissenschaftlicher Verein, Frankfurt-an-der-Oder.
Prussische Bibliothek, Berlin.
Rautenstrauch-Joest-Museum (Städtisches Museum für Völkerkunde) Cologne.
Redaction des Biologischen Centralblatts, Erlangen.
Senckenbergische Naturforschende Gesellschaft, Frankfurt-am-Main.
Verein für Vaterländische Naturkunde in Württemburg, Stuttgart.
Zoological Society, Berlin

Finland.

Abo Akademi, Abo.
Finska Vetenskats Societes, Helsingfors.

Austria.

Intendanz des Naturhistorische Hofmuseums, Vienna.
K.K. Central-Anstalt für Meteorologie und Erdmagnetismus, Vienna.
K.K. Geologische Reichsanstalt, Vienna.

Belgium and the Netherlands.

Académie Royal des Sciences, des Lettres, et des Beaux-Arts de Belgique, Brussels.
La Société Royale de Botanique de Belgique, Brussels.
Musée Teyler, Haarlem.
Netherlands Entomological Society, Plantage, Middenlaan 15, Amsterdam.

Switzerland.

Naturforschende Gesellschaft (Société des Sciences Naturelles), Bern.

France.

Bibliothèque Nationale, Paris.
Musée d'Histoire Naturelle, Paris.
Société Zoologique de France, Paris.
Société de Chimie Industrielle, 49 Rue de Mathurins, Paris.

Italy.

Biblioteca ed Archivio Tecnico, Rome.
Museo Civice di Storia Naturale, Genova.
Museo di Zoologia e di Anatomia Comparata della R. Universita, Turin.
R. Accademia dei Lincei, Rome.
R. Accademia di Scienze, Lettre, ed Arti, Modena.
Società Africana d'Italia, Naples.
Società Botanica Italiana, Florence.
Società Geografica Italiana, Rome.
Società Toscana di Scienze Naturali, Pisa.
Stazione Zoologica di Napoli, Naples.

Spain.

Junta de Ciencies Naturals, Barcelona, Apartado 593.

United States of America.

Academy of Natural Sciences, Buffalo, State of New York.
" Davenport, Iowa.
" Library, Philadelphia.
" San Francisco.
American Engineering Societies' Library, 29 West 39th Street, New York.
American Geographical Society, New York.
American Journal of Science (Editors), Yale University, New Haven, Conn.
American Philosophical Society, Philadelphia.
Arnold Arboretum, Harvard University, Jamaica Plains, U.S.A.
Boston Society of Natural History.
Brooklyn Botanical Gardens, New York.
Chemical Abstracts, Ohio State University, Columbus, Ohio.

Connecticut Academy, New Haven.
Department of Agriculture, Washington, D.C.
Field Museum of Natural History, Chicago.
Franklin Institute, Philadelphia.
Johns Hopkins University, Baltimore.
Journal of Geology (Editors), University of Chicago, Chicago, Ill.
Leland Stanford Junior University, California.
Library, Bureau of Science, Manila.
Lloyd Library, Cincinnati.
Missouri Botanical Gardens, St. Louis, Mo.
Museum of Comparative Zoology, Cambridge, Mass.
National Academy of Sciences, Smithsonian Institution, Washington, D.C.
National Geographic Society, Washington, D.C.
New York Academy of Sciences, 77th Street and Central Park West, New York.
Rochester Academy of Sciences.
Smithsonian Institution, Washington, D.C.
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United States Geological Survey, Washington, D.C.
University of California, Berkeley, U.S.A.
University of Illinois, Urbana, Illinois
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University of Montana, Missoula.
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Brazil.

Escola de Minas, Rio de Janeiro.
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Argentine Republic.

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Museo Nacional de Historia Natural de Buenos Aires, Casilla del Correro.
Sociedad Cientifica Argentina, Buenos Ayres.

Uruguay.

Museo Nacional, Monte Video.

Japan.

College of Science, Imperial University of Japan, Tokyo.

Hawaii.

Bernice Pauahi Bishop Museum, Honolulu.
National Library, Honolulu.
Volcano Observatory, Kilauea, Hawaii Islands.

Java.

Society of Natural Science, Batavia.

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